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Professional Paper 100—A

THE COAL FIELDS OF THE UNITED STATES

GENERAL INTRODUCTION

BY

MARIUS R. CAMPBELL

Professional Paper 100, pages 1-33
Published February 24, 1917

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

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THE COAL FIELDS OF THE UNITED STATES.

GENERAL INTRODUCTION.

By MARIUS R. CAMPBELL.

PURPOSE AND SCOPE OF REPORT.

The growing demand for fuel and the probability that sooner or later the United States will be called upon to furnish supplies to less favored countries has made it desirable for the Geological Survey to take stock of the country's fuel and to determine the quantity, quality, and geographic distribution of the coal still in the ground and available for future use. This report is intended to supply such information regarding the coal fields in the United States, arranged according to the States within which they lie.

The first effort to give to the public a comprehensive description of the great coal-bearing areas of the country was made by the Geological Survey in 1902, by the publication, in the Twenty-second Annual Report of the Director, of 12 papers dealing with the coal-bearing areas of the United States, including Alaska. Unfortunately, this series of papers, although exceedingly interesting and valuable as presenting a summary of the then existing knowledge of some of the coal fields, was lamentably incomplete, for it contained no description of the rich fields of Maryland, West Virginia, eastern Kentucky, and Virginia; and the treatment of many of the western fields was unsatisfactory, for the reason that they had not been examined in detail, and consequently their boundaries and their contents could be described in only a vague and indefinite manner.

Up to the year 1905 the United States Geological Survey had made no effort to examine and map systematically the coal fields of the country, especially of the West; but a number of fields had been specially examined or had been mapped as a part of the general plan of making a geologic atlas of the United States. This lack of activity in the examination of the coal resources was due largely to the lack of interest in such work shown by coal operators, owners, and consumers, as it was then generally regarded as unnecessary in the development of a coal-bearing tract to have any geologic information regarding the lay of the beds and the quality or quantity of the coal, and the consumer purchased his coal with but little thought as to whether or not he was getting the best available fuel for the particular use to which he expected to devote it.

About that time, however, the public began to awaken to the realization of the need of utilizing better the fuel supply and to the further realization that great frauds had been perpetrated in the Western States in procuring valuable coal lands under the homestead act and laws other than the coal-land law, which required the payment to the Government of not less than $10 or $20 an acre and restricted to 160 acres the area that it was possible for one person to acquire. In response to the public demand for the stopping of such frauds and for the better conservation of the fuel reserves of the country, President Roosevelt in 1906 withdrew from entry 66,000,000 acres of supposed coal land, and the United States Geological Survey was requested to classify these lands and appraise their value, so that they might be sold at prices that accorded with the quantity and quality of coal available in them. This was made possible by a new interpretation of the phraseology of the coal-land law of 1873, which specified that coal lands should be sold at not less than $10 an acre if more than 15 miles from any completed railroad and not less than $20 an acre if within 15 miles of a railroad.

In anticipation of this action the Geological Survey had begun in 1905 the systematic examination of coal fields in the public-land States and by 1908 had made sufficient progress in that work to issue the first reasonably accurate map of the coal fields of the country, on a scale of about 120 miles to the inch. In addition to outlining the coal fields, this map differentiates the areas of known coal from the areas that might possibly contain valuable coal and shows also those areas in which the coal-bearing rocks are under deep cover. On this map the coal fields are classified according to the rank of the coals they contain, or at least three great groups are recognized, namely, (1) anthracite, semianthracite, semibituminous, and bituminous coal; (2) subbituminous coal; and (3) lignite. In addition to delineating the coal fields, the map contains an estimate of the tonnage of coal still remaining in the ground and supposedly available for the future needs of the country.

The making of this estimate, crude though it was, marked an important step in the investigation of the Nation's resources, for it was the first attempt to make a quantitative estimate that would enable the public to calculate the length of time the fuel supply might be available. The writer in making this estimate was painfully aware of its inaccuracies and of the fact that even in such old coal-mining States as West Virginia the data were in such shape that an accurate estimate was impossible. Curiously enough, the data available at that time were much more complete for the Western States than for the Eastern States, and the estimates for some of those States were therefore much more accurate. The figures were put forth at that time with two objects in view—first, to give the public the benefit of the best estimate that the Geological Survey was able to make, and, second, to stimulate the activity of others who were working on the same problems. The publication served both its purposes, for the figures were widely used in the conservation discussions that were then being carried on; and a number of State geologists of the older States began to make estimates of their coal resources, with the result that a much greater volume of information became available and much better estimates could be made. Naturally, the estimates made by the writer on entirely insufficient data were modified considerably when additional information was obtained; but for a number of years the result stood nearly as it was originally made.

The next attempt to improve upon the old maps of the coal fields and the estimates of the reserves they contained was made by the writer on invitation of the executive committee of the International Geological Congress for its twelfth session, at Ottawa, Canada, in 1913. The International Geological Congress had several years before decided to consider at each session some subject of worldwide interest, particularly some mineral resource in which all countries would be interested. Thus iron ore was considered at the eleventh session, which was held at Stockholm, Sweden, in 1910, and a monograph summarizing the knowledge then existing on this subject was published. The executive committee decided to take up the subject of coal for consideration at the twelfth meeting, at Ottawa, and the results are incorporated in three large volumes of descriptive text and an atlas showing the coal fields of the world. These volumes are a storehouse of information, but their small edition and great cost make their general distribution impossible. Naturally, in a report covering a subject as important as coal and dealing with the fields of the entire world, each country must be treated so briefly that the description may be considered only a short summary.

The report on the coal fields of the United States, exclusive of Alaska, appears by comparison with some others contained in these volumes to be exceedingly brief—too short, in fact, to afford the ordinary reader the information he desires. The essential features of this report are (1) the map, which was brought up to date for this particular purpose, but which is on a scale too small to be of much practical value; and (2) an estimate of the reserves of the different ranks of coal in the several fields, regions, and provinces. This estimate is the most recent one that has been prepared, and it will be accepted with some modifications for the present report.

Although the volumes published by the Twelfth International Congress are monumental and constitute a remarkable achievement, it was at once realized that they are very inadequate for practical use and that they should be supplemented by more detailed reports on all the countries as soon as possible. Since the publication of the descriptions of the coal fields of the United States in the Geological Survey's Twenty-second Annual Report, in 1902, a large amount of geologic work has been done in the coal fields of this country. The Survey has each year mapped, either in a reconnaissance way or in detail, many thousands of square miles of coal territory in the public-land States of the West, and in addition has been carrying on detailed work in many of the eastern fields. Owing to administrative demands, the work in the West was at first largely of a reconnaissance character, but as time passed it was found necessary to refine methods and to do more careful work, so that in the end sufficient data would be available for a fairly accurate valuation of the land according to the quantity of available coal it contained, a valuation which should be of use to anyone interested in the development of the fields, either as owner, operator, or investor.

In the East the Geological Survey has been or is cooperating with State organizations in the careful survey of parts of the eastern fields. Such work has been carried on in Pennsylvania, Tennessee, and Alabama and is now in progress in Virginia, Illinois, and Kentucky. The State geological surveys of Maryland, West Virginia, Ohio, Tennessee, Iowa, Missouri, and Washington have been active, and good reports have been published relating to the coal in those States.

In view of the great amount of work that has been done since the previous summary was made, it seems opportune to sum up again the existing knowledge regarding the extent and quality of the coals in the various fields. In order to give this report the greatest value and standing, it is proposed, so far as practicable, to have the description of each natural area prepared by the geologist who is most familiar with the field and best acquainted with the local conditions. Not only will this plan be followed within the United States Geological Survey, but State geologists have been invited to prepare the accounts of the coals in their respective States, so that the report may be thoroughly authentic. The State geologists of Maryland, West Virginia, Ohio, Tennessee, Michigan, Illinois, Iowa, Kansas, and Washington have agreed to contribute to this plan, and this cooperation insures excellent results.

As the reports are to be prepared by many authors, it is impossible to assemble all the material at one time, so the State reports will appear as separates as soon as they are ready and will then be included in the final volume or volumes. Where the coal-bearing areas of a State are made up of a number of isolated fields or regions each isolated area will be treated separately in a signed report, and the State separate will be made up of papers dealing with the fields comprised within the State.

RANKS OF COAL.

METHODS OF CLASSIFICATION.

In this report the word "rank" will be used to designate those differences in coal that are due to the progressive change from lignite to anthracite, a change marked by the loss of moisture, of oxygen, and of volatile matter. This change is generally accompanied by an increase of fixed carbon, of sulphur, and probably of ash. When, however, one coal is distinguished from another by the amount of ash or sulphur it contains, this difference is said to be one of grade. Thus "a high-grade coal" means merely one that is relatively pure, whereas "a high-rank coal" means one that is high in the scale of coals, or, in other words, one that has suffered devolatilization and that now contains a smaller percentage of volatile matter, oxygen, and moisture than it contained before the change occurred.

Within the boundaries of the United States there are all ranks of coal, from the coarse, woody lignite of North Dakota and eastern Montana to the highest rank of anthracite in the fields of eastern Pennsylvania. From the earliest days of coal mining in this country it has been recognized that coals differ greatly, not only in the percentage of ash which they contain, but also in their inherent composition. Although the latter distinction was recognized, little or no attempt was made to determine the reason for the difference or the criteria for fixing the limits of different groups of coals. The first serious attempt in this country to devise a scientific basis for the classification of coal was made by Persifor Frazer, jr., of the Second Geological Survey of

Pennsylvania, under the direction of J. P. Lesley. Frazer[1] listed most of the commercial coals of the State and then compared the trade distinctions with the "fuel ratio" (the quotient of the fixed carbon divided by the volatile matter of the proximate analysis). He found that there were in use at that time the rank names of anthracite, semianthracite, semibituminous, and bituminous. He found that in practice the fuel ratios of the coals of the different groups overlapped, but he concluded that these ranks might be established with the following limits:

	Fuel ratio.
Anthracite	100 to 12
Semianthracite	12 to 8
Semibituminous	8 to 5
Bituminous	5 to 0

These ranks, with the boundaries fixed provisionally by Frazer, serve very well for Pennsylvania and for the coals of the great Appalachian trough, extending from northern Pennsylvania to central Alabama, but they do not apply to the great mass of western coals, which at that time were of little or no importance. Most of those persons who were instrumental in developing the coal fields of the West originally came from the East, and they carried with them ideas of coal obtained in the eastern fields, which contained high-rank fuel. Not only that, but most of the coals in the Appalachian region and those in the upper Mississippi Valley are of Carboniferous age and hence are very old; but the coals of the West are Cretaceous and even Tertiary in age and hence, when compared with Appalachian coals, are very young indeed. A difference in character was recognized, and as the western coals are generally inferior they were lumped together and called merely "lignite." The term "lignite" is undoubtedly appropriate for many of the low-rank coals of the West, but it is certainly not appropriate for black, shiny coals that show little trace of woody texture and are capable of producing a coke of fairly good quality. Nevertheless such coals were called lignite and relegated to the lowest rank among coals.

Several persons have attempted to devise schemes of classification based upon chemical composition by which a certain coal could be referred to its proper place merely by means of its chemical analysis, but so far no scheme of this kind has been devised that is applicable to all ranks of coal. Some scheme like Frazer's suits admirably one part of the column but can not be made to fit the other part. Schemes of this kind are so unsatisfactory that the United States Geological Survey has finally decided that it is practically impossible to classify all ranks of coal according to their chemical composition, and that it is necessary to supplement chemical by other criteria. Accordingly, Frazer's scheme, with some necessary modification to make it agree more closely with modern trade practices, has been adopted for the higher ranks of coals, and physical characteristics have been used for the lower ranks. Thus, in the West no one questions that there is coal of the rank of lignite, but it is difficult, if not impossible, to specify what a lignite is in terms of its chemical constituents. Similarly, in the Rocky Mountain region, where the low-rank coals are abundant, there is no question that there is a difference between brown, woody, or amorphous lignite and shiny, black subbituminous coal, but this difference is one that is not clearly defined by available chemical criteria. There is, however, a marked physical difference, although there is no sharp line of demarcation between them. Thus subbituminous coal is black and shiny, whereas lignite is dull and generally woody in texture; subbituminous coal has a greater heating value and carries less moisture than lignite. Altogether the difference between the two is so marked that they are known by different names in the trade, and for that reason, if for no other, they should be classed differently.

In a like manner the distinction between subbituminous and bituminous is not sharp and does not show in a chemical analysis. Subbituminous coal generally carries more moisture than bituminous, but there are so many exceptions to this rule that it has very little value as a means of distinction. There is, however, one marked difference by which they can always be separated, and that is the difference in their behavior under weathering, and as this difference has a marked effect upon their commercial value and use it seems to be a legitimate criterion for separating them into the two ranks, subbituminous and bituminous. The difference in the effect of weathering is due primarily to a difference in the percentage of moisture in the coal, but, as stated above, the percentage of moisture is variable. Subbituminous coals, however, in general contain more moisture than bituminous coal, and on weathering lose their moisture readily. This loss of moisture results in shrinkage and the formation of incipient cracks, which do not conform to the few joint faces but tend to run irregularly. On the other hand, the bituminous coals generally contain a smaller percentage of moisture, so that they shrink very little when they are suddenly dried. They may be very highly jointed and may fall to pieces readily when mined and handled, but their breakage is due to the inherent weakness of the coal, and the cracks almost invariably correspond with the joint faces.

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[1] Pennsylvania Second Geol. Survey Rept. MM, p. 143, 1879.

By using these criteria (part chemical and part physical) it is possible to classify coals and not only to define the general characters of the different groups but to delimit them with considerable accuracy. The United States Geological Survey recognizes the ranks indicated below.

ANTHRACITE.

Anthracite is generally well known and may be defined as a hard coal having a fuel ratio (fixed carbon divided by the volatile matter) of not more than 50 or 60 and not less than 10. Most of it is mined in eastern Pennsylvania, where its peculiar quality is due to regional metamorphism—that is, to the crushing stresses that affected the crust of the earth when the rocks were thrown into the great folds that characterize this region. Small areas of anthracite occur in the West, but generally these coals have been converted to anthracite by the heat of some mass of igneous rock that was thrust into the other rocks while it was in a molten condition. Many such masses take the form of thin sheets, which were forced in between the beds of the other rocks, and consequently for some distance they may lie parallel with the coal beds. If a coal bed is cut by the igneous rock, it may be burned to ashes, made into coke, or converted to anthracite. The product will depend on the presence of air, the intensity of the heat, and the length of time the coal was subjected to the influence of the heated mass. Anthracite is an almost ideal domestic fuel, but it is not well adapted to steam raising unless an absolutely smokeless coal is needed. Many people believe that anthracite has greater heating value than any of the other ranks, but this is not true, as can be seen by a comparison of analyses given on page 31, and by reference to figure 1 (p. 8). Largely on account of its low heating power anthracite is not an economical fuel for steam raising or for use in general manufacturing.

SEMIANTHRACITE.

Semianthracite is also a hard coal, but it is not so hard as true anthracite. It is high in fixed carbon, but not so high as anthracite. It may be defined as a hard coal having a fuel ratio ranging from 6 to 10. The lower limit is uncertain, as it is difficult to say where the line should be drawn to separate "hard" from "soft" coal and at the same time to divide the two ranks according to their fuel ratio. Some hard coals of the anthracite type have a fuel ratio as low as 6.5 or 7, whereas some of the soft coals have a fuel ratio as high as 7 or perhaps more. For this reason it is probable that fuel ratio alone can not be depended upon to separate these two ranks, but that physical properties also may have to be taken into consideration. The change of ordinary soft coal to semianthracite is due to the same causes that produced anthracite, except that the process has not been carried so far in semianthracite, possibly because the action has not been so intense. There is very little semianthracite in this country, so it is only a small factor in the coal trade. Such semianthracite as is mined reaches the consumer generally under the name "anthracite" and is masquerading under false colors.

SEMIBITUMINOUS.

The name "semibituminous" is exceedingly unfortunate, as literally it implies that this coal is half the rank of bituminous, whereas it is applied to a kind of coal that is of higher rank than bituminous—really superbituminous. Semibituminous coal may be defined as coal having a fuel ratio ranging from 3 to 7. Its relatively high percentage of fixed carbon makes it nearly smokeless when it is burned properly, and consequently most of these coals go into the market as "smokeless coals." The best coal of this type has a heating value greater than that of any of the other ranks and is consequently best adapted to raising steam and to general manufacturing that requires a high degree of heat. It is regarded as the best coal for steamship and especially for naval use, as it is nearly smokeless and requires less bunker space per unit of heat than other coals. The coal is generally minutely jointed and is therefore tender and friable. In fact, it is so friable that in mining a large percentage of fine coal is produced, and in transportation many of the lumps are broken to pieces, so that by the time it reaches the consumer, especially if it has been transshipped, it is generally in small pieces. This fineness is by many regarded as detrimental, because the public is accustomed to lump coal which will stand transportation without crushing, but when this coal is used with mechanical stokers and with a grate adapted to its use the fineness of the coal is not disadvantageous. The great bulk of this kind of coal is in the eastern fields, but some is found in the West, where it has been subjected to a slight amount of regional metamorphism or has been heated by some igneous mass.

BITUMINOUS.

The term "bituminous," as generally understood, is applied to a group of coals having a maximum fuel ratio of about 3, and hence it is a kind of coal in which the volatile matter and the fixed carbon are nearly equal; but this criterion can not be used without qualification, for the same statement might be made of subbituminous coal and lignite. As noted before, the distinguishing feature which serves to separate bituminous coal from coals of lower rank is the manner in which it is affected by weathering. Bituminous coal is only slightly affected chemically by weathering unless it is exposed for many years, and then, although it consists of small particles, each particle is a prismatic fragment, whereas coals of lower rank break into thin plates parallel with the bedding.

The definition given above might not indicate that the bituminous rank is a large one, but when it is examined critically it is found to contain a great variety of coals—coals having really little in common with one another. Many attempts have been made to subdivide this great group, but so far no scheme proposed has met with general approval. Many of the better coals of this group will coke or are being coked, but coking coals are not limited to the bituminous rank, for some of the best coke made in the United States is produced from semibituminous coal. Not only is the upper limit of the coking group uncertain, but the lower limit is equally difficult to determine. If the coking property had some definite relation to the chemical composition of the coal as it is at present determined there might be some hope of establishing a class of coking coals by chemical analysis, but no one can say just why a coal will coke, so an actual test in an oven is required to determine whether or not a coal will coke.

Gas coals have been in great demand and such coals must be high in volatile matter, so as to make on distillation a large volume of gas; and as this gas must be relatively free from sulphur the coal from which it is made must contain a very small percentage of that element. In recent years the making of gas for illuminating and heating has undergone a great change, water gas largely taking the place of the gas distilled from coal; and as this gas requires no particular quality of coal, the demand for "gas coals" has been greatly reduced and probably in the near future will disappear.

Cannel coal is very rich in volatile matter, is generally high in hydrogen, and therefore burns with a great heat and a long flame. It is essentially a gas-making coal and in the early days was used extensively for this purpose, as well as for the distillation of oil. As a source of oil it could not compete with petroleum derived from wells, and soon after oil was discovered in the earth in 1859 the business of distilling oil from coal in this country was discontinued. Cannel coal owes its richness to the fact that it is composed almost entirely of the spores, spore cases, seed coats, and resinous or waxy products of such plants as lived at the time of the existence of the coal swamp. In such swamps, as in those of to-day, there was doubtless in places open water, into which the spores and seed cases floated and, becoming water-logged, sank to the bottom and in time produced cannel coal. The absence of woody material in such coal gives it a regular texture and grain that are not found in any other coals. As a result, it breaks like glass, with a conchoidal or shell-like fracture, and owing to its richness in inflammable material the best of it will ignite readily when a lighted match is held in contact with a small splinter of it. As the nature of cannel coal is due to the kind of material of which it is composed, it follows that there may be all kinds of cannels, corresponding in a general way with the various ranks of coals. Ashley[1] has recently proposed the following classification of cannel coal:

1. Subcannel coal:
    (a) Brown subcannel, of brown coal or lignite rank.
    (b) Black subcannel, of subbituminous rank.
2. Cannel coal, of bituminous rank:
    (a) Boghead cannel (fuel ratio less than 0.5).
    (b) Typical cannel (fuel ratio between 0.5 and 1).
    (c) Lean cannel or semicannel (fuel ratio more than 1).
3. Canneloid, semibituminous coal, semianthracite, or anthracite.

Cannels which are of the rank above bituminous have lost their original richness and therefore do not deserve to be called cannels.

Other kinds of coal, such as "block" and "splint," are recognized in the trade, but the characteristics of these coals are physical and are found in only a small group of coals. Some of the "block" and "splint" coals are very hard, almost as hard as anthracite, but they are generally woody in texture and contain much mineral charcoal. They are valuable coals in the market, but usually their development is so local that they are not of much importance in a general classification of coal.

As the great group of bituminous coal includes all grades from the poorest western bituminous coal to the highest-rank coal in the Appalachian region, exclusive of the semibituminous coal, the writer has, for convenience, divided the group and represented it on the general map of the coal fields of the United States in two colors—one indicating all coals having, in the air-dried sample, a calorific value (in British thermal units) of more than 12,500, and the other indicating all bituminous coals having, in the air-dried sample, a calorific value of less than 12,500. This is a practical separation according to heating value, which, after all, is the principal criterion for determining the relative values of coals.

SUBBITUMINOUS.

The term "subbituminous" is adopted by the Geological Survey for what has generally been called "black lignite," a term that is objectionable because the coal is not lignitic in the sense of being distinctly woody, and because the use of the term seems to imply that this coal is little better than the brown, woody lignite of North Dakota, whereas many coals of this rank approach in excellence the lowest grade of bituminous coal. Subbituminous coal is generally distinguishable from lignite by its black color and its apparent freedom from distinctly woody texture and structure, and from bituminous coal by its loss of moisture and the consequent breaking down or "slacking" that it undergoes when subjected to alternate wetting and drying. As the percentage of moisture is an important matter in buying and shipping coal, and as the slacking on exposure to the weather makes it necessary to ship in box cars and to guard carefully against spontaneous ignition, there is a great commercial difference in these two kinds of coal which the Geological Survey has recognized by putting them in different ranks. Despite the many drawbacks in the shipment and use of subbituminous coal it has found a ready market in much of the western country, because it is a very clean domestic fuel and ignites with little difficulty.

Subbituminous coals differ considerably in chemical composition and in physical appearance. Some are banded like much of the bituminous coal, and some are essentially cannel in physical and chemical make-up. In general, the Cretaceous and younger coals of the West contain a smaller percentage of sulphur than the older coals of the East, and as some of them are high in volatile matter they would doubtless be excellent coals for making gas, either illuminating gas or producer gas for generating power.

LIGNITE.

The term "lignite," as used by the Geological Survey, is restricted to those coals which are distinctly brown and either markedly woody or claylike in their appearance. They are intermediate in quality and in development between peat and subbituminous coal. As the moisture of lignite as it comes from the mine generally ranges from 30 to 40 per cent, its heating value is low; and the consumer can not afford to pay freight for any great distance on so much water. Also it parts with much of this moisture very readily when exposed to the weather and so falls to pieces or slacks much more readily and completely than subbituminous coal. On this account it is more likely to ignite spontaneously and must be handled even more carefully than subbituminous coal and stored in a place where it will not be exposed to alternate wetting and drying. Lignite is mainly marketed near the mine, as a domestic fuel, but at a few places in North Dakota and Texas it is shipped to near-by towns and used for general manufacturing purposes.

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[1] Ashley, G. H., Cannel coals in the United States: U. S. Geol. Survey Bull. — (in preparation).

At the Government testing plant at the St. Louis Exposition North Dakota lignite was found to be an excellent fuel for making producer gas, and probably in the future it will be

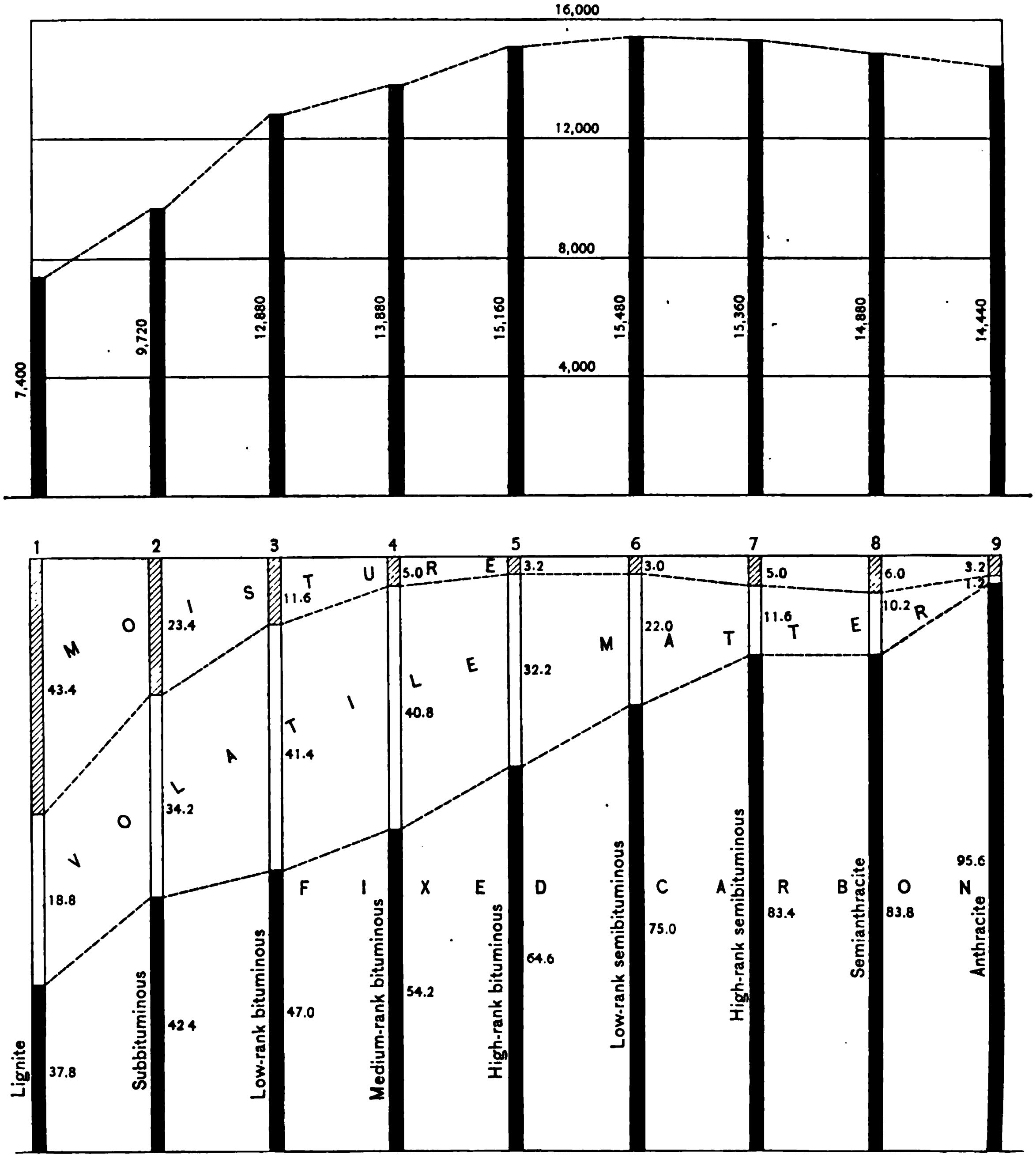

FIGURE 1.—Diagrams showing the chemical composition and heat efficiency of the several ranks of coal. Upper diagram: Comparative heat value of the samples of coal represented in the lower diagram, computed on the ash-free basis. Lower diagram: Variation in the fixed carbon, volatile matter, and moisture of coals of different ranks, from lignite to anthracite, computed on samples as received, on the ash-free basis.

much more largely used for producing power than it has been in the past. Just how this will be accomplished is difficult to determine, but it is possible that large producer plants may be erected at the mines and the lignite converted into electric energy and delivered by long-distance transmission lines to towns within a radius of 200 miles or to the railroads in this region or in contiguous territory. Lignite has recently been used in powdered form, and it may possibly be better utilized in this way. As some of the Texas and Arkansas lignites are in effect undeveloped cannel coals, it seems possible that when the supply of petroleum is much less than the demand, the lignite may be used for the distillation from it of oil and the various by-products that are now obtained in Scotland from oil shale. Lignite can also be manufactured into hard briquets, which make an excellent fuel, but so far the cost of manufacture has been prohibitive.

COMPARISON OF THE DIFFERENT RANKS.

Figure 1 is a graphic representation of the proximate chemical composition of the various ranks of coal and of their heat-producing values. The lower diagram shows the fairly regular increase in fixed carbon from lignite to anthracite, though it must not be supposed that the lines for all coals are as simple as those shown in the diagram. The analyses upon which the diagram is based are, however, actual analyses selected from those given in the table at the end of this introduction. No. 1 represents the analysis of a typical North Dakota lignite which as it comes out of the mine has a moisture content of about 40 per cent. It also contains about 5.5 per cent of ash, but as ash varies irregularly without regard to the rank of the coal the analysis has been recalculated to the ash-free basis, thus eliminating ash from consideration. All the other analyses have been similarly recalculated. No. 2 represents a subbituminous coal from Wyoming, having a moisture content of 23.4 per cent; Nos. 3, 4, and 5 represent various ranks of bituminous coal, the lowest one being from Indiana, the second from Ohio, and the third, or highest, from the Pittsburgh district of Pennsylvania; Nos. 6 and 7 represent semibituminous coal from the Windber district of Pennsylvania; No. 8 represents semianthracite; and No. 9 represents some of the best anthracite of the Pennsylvania region. The diagram shows clearly that the fixed carbon increases very markedly from lignite to anthracite; that the moisture of the higher-rank coals is small and about the same quantity in each, but increases rapidly from medium-rank bituminous coal to lignite; and that the greatest development of volatile matter is not at either end of the series but in the lower ranks of bituminous coal.

The upper diagram represents the heat value of the same coals on a similar ash-free basis. There is a very general misconception regarding the heat value of anthracite as compared with that of lower-rank coals. Many persons think that because anthracite commands a higher price it must necessarily be a better heating coal than the soft varieties, but this diagram shows conclusively that it is not and that the best coal for heat production is No. 6, or low-rank semibituminous coal. Anthracite commands a higher price than soft coal because of its suitability for domestic use and because of its freedom from smoke, soot, and waste.

From the diagram it might be inferred that the heat value of a coal depends directly upon the amount of fixed carbon that it contains, but this can not be true, for the heat value of pure carbon is only 14,580 British thermal units,[1] whereas coal No. 6 has a heat value of 15,480 British thermal units. Coal derives its heat value mainly from two elements, carbon and hydrogen, the carbon having a heat value of 14,580 British thermal units and the hydrogen a heat value of 62,000 British thermal units.[1] The greater heating power of the low-rank coals as compared with anthracite is due to the fact that these coals contain a considerable quantity of available hydrogen,[2] which when burned produces a much greater heat than the same weight of carbon.

Either diagram well illustrates the slight value of lignite as compared with the higher-rank coals and makes it possible to understand that Pennsylvania and West Virginia coal can be hauled by rail to Lake Erie, shipped by vessel to Duluth or Superior, hauled 400 or 500 miles inland, and then sold in direct competition with lignite mined in the vicinity.

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[1] Richards, J. W., Metallurgical calculations, p. 16, 1906.

[2] W. S. Parr (The composition and character of Illinois coals: Illinois Geol. Survey Bull. 3, p. 37, 1906) defines available hydrogen as follows: "By available hydrogen is meant that part of the hydrogen content which is free to enter into combination with oxygen for the production of heat, as distinct from that hydrogen present which already has * * * the necessary equivalent oxygen for the formation of water, and consequently [is] noncombustible."

CLASSIFICATION OF THE COAL AREAS OF THE UNITED STATES.

For convenience in describing the areas underlain by coal-bearing rocks, some scheme of names and classification of areas is essential. The plan adopted is shown in Plate I, the large map in the pocket of this report. Although coal areas might be subdivided or combined indefinitely, the Geological Survey recognizes four classes, which, beginning with the smallest, are called district, field, region, and province.

COAL DISTRICT.

"Coal district" is a term applied only to developed coal areas. It is already in common use in the trade for an area in which mining has been developed around a fairly definite center, but it also has been loosely used as synonymous with "coal field." A district is generally small, and the term is restricted to areas in which mines are developed continuously on a given bed or beds, and the coal is generally known in the trade by some distinguishing feature, such as a trade name, or by some physical characteristic upon which it is advertised and sold. Districts are generally named from the leading town in them, or from the town at which mining first started or which first achieved distinction in producing this particular kind of coal. From the very nature of the case districts are small, but it is not possible to set definite limits to the area that should be classed as a district.

COAL FIELD.

A coal field is an area of coal-bearing territory next larger than the district. Its recognition is based less upon trade practices and uses than that of a coal district, and therefore it has more of the natural features to characterize it. The term "field" is at present used very loosely, and in many ways it is not advisable to attempt its close restriction. As used by the Geological Survey, it is applied to an area generally larger than a district, but still to a well-defined compact area. In this respect it differs from "region," the term for the next higher division. Small areas or basins that are separated from one another or from the main coal area are called fields, especially if their coal is of fairly uniform composition and value. "Field" is also applied to a certain area which has become prominent because of the kind of coal it produces, but which is not necessarily limited to certain centers of production. Some of the best-known fields of this class are the Pocahontas field of Virginia and West Virginia, the New River field of West Virginia, the Georges Creek field of Maryland and West Virginia, and the Windber field of Pennsylvania. These fields have definite outlines, corresponding with the extent of the bed or beds of coal upon which the field was established or with the limits of coal of a certain quality that influences its sale and use. In large areas of coal-bearing rocks, like that of Illinois, there are many districts or centers of production, but it is also necessary to recognize the larger divisions corresponding with those just mentioned. In Illinois, however, there are no well-defined limits depending on quality of coal or upon natural features, for the region is fairly well and uniformly developed and the quality of the coal does not vary markedly throughout the State. Under such conditions it would be of little value to mark off definite fields, and they would not be used by many; therefore it has been decided that in such areas fields may be recognized as a matter of convenience and hence may vary in different reports, for a division that would be convenient to one person would not necessarily suit the needs of another. It is therefore proposed to consider such a State as Illinois as made up of an indefinite number of coal fields, the limits of which should be defined by the person making the subdivision, and the limits made by one person should not necessarily agree with or control those made by another.

COAL REGION.

As a matter of convenience, coal fields may be grouped into larger divisions called "regions." Such grouping is generally designed to bring together coal fields that have some feature or features in common, thus enabling them to be considered as a whole or separately as the problem may demand. The most striking subdivision of a region is in Colorado and New Mexico, where the great area of coking coal in the eastern parts of these States extends across the line from one State into the other. The Colorado portion is well known as the Trinidad field and the New Mexico portion is equally well known as the Raton coal field. Both names are appropriate and needed, but in many discussions it is necessary to consider them together as a unit, for they are as nearly a unit as it is possible for two coal fields to be. For this reason they are here considered together as the Raton Mesa coal region. Likewise, many other areas are essentially a combination of fields and therefore should properly be classed as regions. Good examples are the anthracite region of Pennsylvania; the western coal region in Iowa, Missouri, Kansas, Oklahoma, and Arkansas; and the numerous deep basins of the Rocky Mountain States.

COAL PROVINCE.

As fields are grouped into regions, so regions are grouped into much larger divisions, called "provinces." These, as shown on the accompanying map, are the Eastern province, Interior province, Gulf province, Northern Great Plains province, Rocky Mountain province, and Pacific Coast province. The grouping into provinces is made largely for convenience in considering broad questions of geologic age, geologic structure, quality of coal, and transportation. In a province, as in a smaller division, there is a certain amount of unity in the physical features of the coal fields of the province or in the quality of the coal. Some provinces contain all ranks of coal, and the fields are grouped together because of their geographic positions, their structural features, or the age of the coal beds.

THE COAL AREAS.

EASTERN PROVINCE.

The Eastern coal province contains probably nine-tenths of the high-rank coal of the country. It is considered as made up of the anthracite regions of Pennsylvania and Rhode Island, the Atlantic coast region of Virginia and North Carolina, and the great Appalachian region, which embraces all the bituminous and semibituminous coal of what is generally known as the Appalachian trough.

The Rhode Island anthracite region, although known since 1760, is of little economic importance, for the coal has never been mined for a long period on a commercial scale, and judging from its composition and the metamorphism of the surrounding rocks, it seems doubtful whether it will ever have more than a local value, if it is worked at all. The coal is more highly metamorphosed than that of Pennsylvania, so that some of it is mined and sold as graphite. It also carries a large percentage of ash, which makes it an expensive fuel to mine and to use.

The Pennsylvania anthracite coal region is so well known that it needs little mention here. It is described in detail in the chapter on the coal fields of Pennsylvania. In the trade generally the anthracite region is considered as made up of four fields known as the Northern, Eastern Middle, Western Middle, and Southern. In 1914 these fields together produced 90,821,507 short tons, or 99.9 per cent of the anthracite mined in the United States.

The Atlantic coast region is of very little practical importance at the present time, for its coal beds are worked either not at all or on a scale so small as to be negligible. The Richmond field or basin, however, has the distinction of being the scene of the first development of bituminous coal in this country, mining having been begun there in 1787. The coal is generally of high rank, some being semianthracite; but the conditions of mining are not good, and the coal can not at present compete with the better coals of the Appalachian region.

The Appalachian region is the greatest storehouse of high-rank coal in the United States, if not in the world. This near-by almost inexhaustible supply of high-grade fuel has been the foundation of the development of the blast furnaces, the great iron and steel mills, and the countless manufacturing enterprises of the Eastern States. The Appalachian region is a compact area of coal-bearing rocks, which in general lie in a deep trough. The trough shape is well marked in its northern part, and the middle line or axis runs nearly through Pittsburgh and thence southwestward to the vicinity of Huntington, W. Va., on Ohio River. The lowest coal bed, if present in the deepest part of the trough, would be about 2,000 feet below the surface. The rocks in this great trough are thrown into a large number of minor wrinkles or anticlines (upfolds), especially on its southeastern side. These small folds generally bring to the surface the harder rocks just beneath the coal-bearing beds, and consequently they form ridges or mountains, as they are called in Pennsylvania and West

Virginia. These die out toward the southwest, but they exert a marked effect upon the coal beds exposed at the surface as far south as Kanawha River. In southern Virginia and Kentucky the trough flattens very decidedly, and as a consequence the coal beds are not so deep, but their outcrops cover a wider territory. In Tennessee the trough character is scarcely apparent and the coal-bearing rocks appear to be nearly horizontal but are broken up by several small folds similar to those noted in the northern part of the region. The effect, however, is very different, for owing to the flatness of the rocks the streams have cut away the upbending folds, leaving great longitudinal valleys instead of anticlinal ridges, and narrow, flat, intervening troughs of coal-bearing rocks. The same kind of structure, except that the troughs are more pronounced, is seen in the coal fields of Alabama, but toward the southwest the rocks gradually descend, and near Birmingham they begin to pass beneath the later rocks (Cretaceous) that were deposited on the Gulf Coastal Plain. This cover becomes deeper and deeper toward the southwest, until, in the vicinity of Tuscaloosa, the coal-bearing rocks disappear and nothing is in sight but the soft sand and clay of the younger formations.

Along the western margin of the Appalachian region the coal beds dip very slightly toward the east and there are no outliers of any consequence, but on the eastern margin the rocks are much more severely folded and there are many synclines (downfolds), which, by the cutting back of the river valleys, have been separated from the main area and now form isolated natural fields. Among the most prominent of such outliers on the east side are the Broad Top field, in central-southern Pennsylvania; the Georges Creek and Upper Potomac basins, in Maryland and West Virginia; the Lookout Mountain field, in Georgia and Alabama; and the Coosa and Cahaba fields, in Alabama. There are also a number of long, narrow outliers in southern Virginia, which properly do not belong with the Appalachian region but which for convenience will be so classed. These fields contain thin and irregular coal beds of Mississippian ("Lower Carboniferous") age. They are the only coals of this age and are the oldest coal beds of commercial importance in the country. Many of them are of high rank, but on account of their irregularity and impurity they have not been extensively developed.

The coal of the Appalachian region is generally of high rank but shows considerable variation, mainly in an east-west direction. In the reports of the Second Geological Survey of Pennsylvania it was clearly pointed out that the percentage of fixed carbon in the coals of that State increases from west to east, and also that the volatile matter decreases in the same direction. The result of this progressive change is that the coals on the eastern margin of the region are of much higher rank than are those on the western margin. White[1] has recently shown that the same progressive change is characteristic of the entire region, and he has drawn contours of equal percentages of fixed carbon showing the change. The well-known fact that the fields of semibituminous coal are limited to the eastern margin of the region accords with this progressive devolatilization of the coals toward the east. Even along this margin they are irregularly disposed, and White has shown that this irregularity is due to variation in the pressure exerted on the coal-bearing rocks at the time of the great movement which folded the rocks of the Appalachian region. As this thrust was transmitted through broken and folded rocks it acted irregularly; in places the movement was taken up by the folding and faulting of the rocks, and in other places the thrust was transmitted direct to the coal-bearing rocks, and materially affected the quality of the coal. As the coals are the softest rocks involved in the thrust, they were transformed according to the intensity of the pressure, the transformation being greatest along the east side of the region, where the thrust was most severe, and least along the west side, where the thrust was least. Two other elements that materially affect the quality of the coal of a field or region are the sulphur and the ash. The variations in the quantity of these substances are due to original differences in the conditions under which the coal was laid down and to conditions that permitted mineral-bearing waters to circulate through the coal bed since it was formed. These conditions can not be determined, so the variations in composition due to these factors can not be foretold to any great extent.

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[1] White, David, Some relations in origin between coal and petroleum: Washington Acad. Sci. Jour., vol. 5, pp. 189-212, 1915.

During the deposition of the coal beds the Appalachian region was doubtless a great swampy country near sea level, but even then it appears to have been in the form of a basin, whose deepest part was in western West Virginia. On account of this depression there was probably open water here, at least during part of the time when the coal beds were being deposited, for the coals are generally absent from this part of the region, as is shown by the map (Pl. I, in pocket). These beds, if present, would be deeply buried, but their absence has been revealed by deep drilling done to find oil and gas.

INTERIOR PROVINCE.

The Interior province includes all the bituminous coal fields and regions near the Great Lakes, in the Mississippi Valley, and in Texas. It is made up of four distinct regions—the northern region (Michigan); the eastern region (Illinois, Indiana, and western Kentucky); the western region (Iowa, Missouri, Kansas, Oklahoma, and Arkansas); and the southwestern region (Texas).

As these regions, with one exception, are not near mountainous uplifts, the coals are of low rank, for little pressure has been exerted upon them, and their change or devolatilization has been only such as resulted from the long-continued pressure of the overlying rocks. This statement is eminently true of the northern and eastern regions, the Iowa and Missouri portions of the western region, and the southwestern region; but as the southern part of the western region is near or a part of the mountainous area of uplifted rocks in Arkansas, the coal beds have been materially affected. They have been devolatilized to about the same extent that the Appalachian coals have been devolatilized by the great pressures that folded the rocks of the Appalachian Valley. The Ouachita disturbance changed the coal of Arkansas to semibituminous coal, or even to semianthracite, and the pressure has been effective as far west as a point about 50 miles within Oklahoma. Beyond this point the coal has not been converted into semibituminous coal but has been considerably altered, so that to-day it is regarded as superior to the coals of adjacent fields. The pressure also has devolatilized the coals farther north, in Kansas, changing them to coals of considerably higher rank than the coals of the region farther north. The coals of the northern part of this province have a large moisture content, which of course produces low heating value and a generally poor coal.

The northern and eastern regions are in the form of wide, generally shallow basins in the coal-bearing rocks, the deepest parts of which lie near their centers, toward which the beds dip lightly from the margins. The coal-bearing rocks in the western and southwestern regions do not lie in basins, or rather they constitute the eastern margin or rim of the greatest basin on the continent—the basin of the Great Plains. Throughout Iowa, Missouri, Kansas, Oklahoma, and Texas the coal-bearing rocks dip lightly westward and pass beneath the later rocks of the Great Plains. They emerge in the Rocky Mountains, on the west side of the Great Basin, but here the rocks of this age are not coal bearing, and no one knows where the change occurs from one to the other. The passing of the coal-bearing rocks under the cover of the later rocks of the Great Plains is shown on the map by the dotted pattern in the light tint. That part of the western region which lies in Arkansas is merely an eastern outlier in which the rocks are greatly folded, and in which the coals are therefore much devolatilized and improved in rank; but this area is still connected with the main region to the west.

Although the coal of the Interior province as a whole is not equal in quality to that of the Eastern province, it is very extensively mined and is used for heating and for generating power in the many cities and towns of the Mississippi Valley and the Great Lakes. In fact, the presence of these extensive coal fields in near proximity to the rich agricultural lands of this country and to the avenues of transportation—railroads, lakes, and rivers—has been largely instrumental in developing the great manufacturing centers of Chicago, St. Louis, and Kansas City and has been an important factor in the development of the railroad systems that gridiron this fertile country in all directions.

GULF PROVINCE.

The Gulf province is at present of slight commercial importance. The coal is mostly lignite, and it has been mined at only a few localities in the State of Texas. The same kind of lignite occurs in Arkansas, Mississippi, and Alabama; but, owing to the presence of high-rank coal near by in the fields of Arkansas, western Kentucky, and Alabama, it has not been prospected except in a few areas. The lignite is contained in rocks of Eocene (early Tertiary) age, generally sandstone and clay, that are so soft as to make mining difficult and expensive.

The old idea that lignite is of recent formation and is of low rank because of that fact is generally true, but there are many exceptions. Some of the most valuable coal beds in the Western States are of the same age as the Texas lignite, yet they are of high rank. A study of the coal fields of the United States shows clearly that, although age is a factor in the alteration of coal, it is generally not the principal one. The controlling factor is the presence or absence of disturbances in the rocky crust of the earth, either in the coal field or close to it. Thus in the lignite fields of Alabama, Mississippi, Arkansas, and the northern part of Texas there have been no mountain-making disturbances since the lignite was formed. It may be said that the region is in its native condition; but near the Mexican border, in the vicinity of Laredo and Eagle Pass, the coal has been changed to a higher rank by the uplift of the Sierra Madre Oriental, of Mexico, which lies only a short distance to the southwest. Similarly, in Washington and in other States of the West the disturbances which have produced the mountains have so changed the coal that, instead of being lignite, it is now bituminous coal or even anthracite. The lignite of northern Texas and southern Arkansas is of better quality than that of the central part of Texas, the difference being due probably to the different conditions under which it was deposited. The lignite in the southern part of Texas seems to have been formed largely of trees and stems, which are clearly visible in the lignite to-day; but in the northern part of the State there appears to have been open water in which the accumulation of organic matter consisted mostly of spores, seeds, and spore cases that grew on the plants in the surrounding areas. Such wood as fell or drifted into the water decayed, for the most part, so that its resin contents fell to the bottom, there to mingle with the spores and other resistant detritus. The result is that this lignite is very rich in bituminous matter; it is subcannel coal or cannel coal in the process of formation. The rocks containing the lignite dip gently toward the Gulf and pass under younger rocks. These effectually conceal the Eocene rocks and the beds of lignite, but it does not seem probable that the lignite extends very far in this direction, for when the lignite was formed this area was a low coastal plain, which sloped gently to salt water, and as the swamps were limited to the land area they were probably not very wide.

NORTHERN GREAT PLAINS PROVINCE.

The Northern Great Plains province includes all the coal fields in the Great Plains east of the Front Range of the Rocky Mountains. In this province the rocks generally lie flat or are but little disturbed, and in consequence the coals are of low rank, being either lignite or subbituminous, except in a few of the basins near the mountains, where the forces that caused the upheaval have locally changed the coal to higher rank. This progressive increase in rank toward the regions of mountain making is apparent in this province, as may be seen not only by comparing the coals of the different fields or basins, but by comparing many of the coals within a basin, region, or field.

The largest coal region in this province is the Fort Union region, lying in North Dakota, South Dakota, Montana, and Wyoming. The northeastern part of this region consists of a very broad, flat basin, in which the dips on the margin are so slight as to be perceptible only by the aid of a level. The southwestern extremity is more sharply folded, consisting of a rather broad, flat trough lying between the great upfold of the Bighorn Mountains on the west and the lower dome of the Black Hills on the east. Although the Fort Union region incloses the Black Hills in a great semicircle the coals there show little or no effect of that uplift, but they do show a decided change toward the Bighorn Mountains. Thus throughout North and South Dakota and northeastern Montana the coal is a brown woody lignite with a moisture content, as it comes out of the ground, of 40 to 45 per cent, but in the vicinity of Miles City, Mont., the brown lignite begins to lose its apparently woody structure and to take on the black color and the general appearance of a subbituminous coal. The change is, however, very gradual, and throughout a zone 15 or 20 miles in width can be seen the mingling of the two types; probably no two geologists would agree on the position of the line marking the place where one leaves off and the other begins. The subbituminous coal in southern Montana is of very poor quality, but farther southwest, in Wyoming, it improves until it reaches its best development in the vicinity of Sheridan, Wyo., where it has been mined extensively for a number of years. At this place the moisture content of the coal as it comes from the mine is only about 25 per cent, and for this reason alone its heating value is 30 per cent higher than that of the lignite of North Dakota.

Many of the coal beds in the Fort Union region are thick, those that are worked measuring from 3 to 40 feet. In almost every section of land that has been carefully examined there have been found a number of thick beds, so that the quantity of unmined coal or lignite in this region is very great.

The lignite and subbituminous coal of this region, as well as that of most of the other fields and regions of this province and of the Rocky Mountain province, ignite easily, and many of them have been burned along the outcrop. Some of the beds are now on fire and are objects of curiosity to those who are not familiar with the country. The heat generated by the burning has been in many places so intense as to partly fuse the overlying shale or sandstone, producing a peculiar, slaglike material of a deep-red color. In other places the heat has not been sufficient to melt the adjacent rock but has changed its color to a dull red, resembling that of brick. Red hills and ridges, whose color is due to the burning of the coal, are common in the western fields and are considered indications of the former presence of coal beds. The depth to which burning extends depends on the depth of cover, for the coal can burn only to depths to which air is accessible; consequently burning is generally limited to a few hundred feet. This low-rank coal also ignites easily in mining, and many mines have had to be permanently abandoned because of fires.

There is very little mining in the Fort Union region, because the inhabitants are engaged chiefly in raising stock and farming, and there are no large towns or cities in which much manufacturing is carried on. The absence of manufacturing explains in part the lack of mining, but the greatest drawback to the establishment of mines is the poor quality of the lignite, which precludes its use as a fuel in many manufacturing processes. Although winter in this region is very severe and fuel is in great demand, those who have attempted to mine the lignite have found difficulty in marketing it in competition with high-rank Pennsylvania and West Virginia coal shipped over the Great Lakes and thence by rail to the lignite region. In the southwest end of the region, where the coal is of the subbituminous rank, the operators have been more successful in opening mines and in building up a large trade. The two centers of production are Sheridan and Glenrock, near Douglas, Wyo., and the coal mined around these centers finds a ready market, especially in the north, where better coal is difficult to obtain.

Although the coal in that part of the Fort Union region which surrounds the Black Hills shows little effect of the upheaval that formed the hills, the coal found immediately on the flanks of the uplift shows a decided improvement in quality as a result of the formation of the Black Hills. The region containing this high-rank coal is rather small and lies entirely on the west side of the uplift. The coal is contained in rocks of Lower Cretaceous age and corresponds with the coal mined at Sand Coulee, south of Great Falls, Mont. The principal center of development is at Cambria, north of Newcastle, Wyo. The coal is of bituminous rank and has been used largely in the manufacture of coke. The coal bed, however, has many partings of shale, and both the coal and coke therefore contain so high a percentage of ash that they can not easily compete with the lower-rank coals of adjacent regions.

Coal like that of the Sheridan district, though perhaps of somewhat better quality, is rather extensively mined in the Bull Mountain field, on Musselshell River. This field is comparatively new, its development dating from the building of the Pacific coast extension of the Chicago, Milwaukee & St. Paul Railway, in 1908. The field is small, having an area of about 1,000 square miles, but it includes a number of beds, some of which attain considerable thickness. The coal is of the same geologic age as the lignite in the eastern part of Wyoming and in North Dakota, but here it has been changed to a high-rank subbituminous coal, about equal to the best subbituminous coal of the Northern Great Plains and Rocky Mountain provinces.

In the Milk River valley and along Missouri River south of the Bearpaw Mountains there is considerable coal, but the beds are generally thin or are only locally expanded into beds thick enough to be of present commercial value. Another obstacle to the development of these fields is the deep cover of glacial drift, which, north of Missouri River, makes the tracing of coal beds and their exploitation very uncertain. The coal is generally subbituminous, but in places it is of the bituminous rank.

The highest-rank coal in this part of the province is that in the Great Falls and Lewistown fields, of Cascade and Fergus counties, Mont. This coal is bituminous and for a number of years was mined and coked at Belt to supply the copper smelters at Anaconda. The coking coal is limited, however, to this locality, and the manufacture of coke from it was discontinued several years ago. The coal contains a large percentage of impurities and has therefore not met with as ready a sale as was expected when the mines were first opened. The coal is mined somewhat extensively for steaming and domestic use in the region round about the mines.

Farther south, in Colorado, the next field of consequence is generally known as the Denver region. This region extends from the Wyoming line southward as far as Colorado Springs. The coal is extensively mined northwest of Denver and to some extent at Colorado Springs. It is subbituminous and finds a ready market in and about Denver and Colorado Springs as a domestic fuel. The coal northwest of Denver is mined along the upturned edge of the coal-bearing rocks at the foot of the mountains, and here it is a fairly good coal of its class; but that at the southern end of the region appears not to have been so greatly affected by the uplift of the mountains and is consequently of much lower rank.

The Canon City field is a small basin of coal-bearing rocks in the great reentrant of the mountain front at Canon City. Owing to its proximity to the mountain uplift the coal has been changed to the bituminous rank, but it carries so high a percentage of ash that its sale in competition with cleaner coals is difficult, especially for domestic use. In the early days of railroad building in Colorado (about 1878) there was keen rivalry between the Denver & Rio Grande and Santa Fe railroads for the possession of this field as a source of locomotive fuel, but although both roads gained access to it the coal has been somewhat disappointing, as its heavy ash content makes it an undesirable fuel for this purpose. Many mines have been opened, and the coal reaches a large market along the mountain front.

The Raton Mesa region, in the southern part of Colorado and the northern part of New Mexico, contains the most valuable and highest-rank coal in this province. The Colorado portion is generally known as the Trinidad field and the New Mexico portion as the Raton field. The rocks lie in a basin-shaped structure, but the edge next to the mountain is sharply upturned and broken through by the old volcanic stock and dikes of the Spanish Peaks. As this basin is filled with younger rocks to a depth of at least 7,000 feet the coal-bearing rocks are deeply covered, and mining has been limited largely to the eastern margin of the region. By the great stresses produced in the folding of the rocks, and possibly by the heat evolved from the stocks and dikes of igneous rocks, the coal has been so much altered as to become of higher rank than any other coal found in this province, except possibly that of the Black Hills. The coal in the southern part of the region makes excellent coke, and the product of the ovens supplies most of the smelters in the Rocky Mountain province.

ROCKY MOUNTAIN PROVINCE.

Until within a few years the coal resources of the Rocky Mountain coal province were largely unknown except a few areas of high-rank coal in Colorado and neighboring States, which were exploited by some of the large steel companies or railroad corporations. Since 1905 the United States Geological Survey has examined most of these fields, either in reconnaissance or in detail, and now the fields of this province are almost as well known as those of the Eastern or Interior provinces.

The coal-bearing formations of the Rocky Mountain province are of Cretaceous and Tertiary (Eocene) age, and doubtless originally extended in almost unbroken sheets throughout the province. Since the deposition of the earliest of these beds the province has been greatly disturbed by movements in the crust of the earth, which resulted in the formation of great mountain ranges. The areas between the ranges were either depressed or remained stationary while the movement was in progress, so that great intermontane basins or depressions lie in the mountainous region. Most of these basins are floored with coal-bearing rocks of either Cretaceous or Tertiary age or are underlain by such rocks at a greater or less depth. In many basins the coal is not so deep but that it may in the future be reached by deep shafts; but in a few it lies so deep that it probably can never be mined.

The Rocky Mountain province contains a greater variety of coal than any other province in the United States. The coal ranges from lignite to anthracite and includes all the ranks described in this paper, though the prevailing ranks are subbituminous and low-grade bituminous. The coal is mined rather extensively, the greatest centers of development being Red Lodge, Mont.; Rock Springs and Kemmerer, Wyo.; Crested Butte and Durango, Colo.; Castlegate and Sunnyside, Utah; and Gallup, N. Mex.

In Montana the coal fields of the Rocky Mountain province are neither large in area nor of great commercial importance. Persistent efforts have been made to develop the fields that contain the best coal, especially in the vicinity of Livingston, at Trail Creek, Chestnut, and Electric; but for various reasons mining has not been successful, and the only mine now in operation is a small one in the Trail Creek field. The coal in these fields is bituminous and has been coked near Livingston and Electric, but the beds are thin and greatly disturbed, and the coal is too dirty to compete with other coals in the market.

Many of the areas shown on the map (Pl. I) are small basins in lake beds in the mountain valleys, which contain in places thin beds of lignite. These are probably of Miocene (later Tertiary) age.

The most important area in this part of the State is the Red Lodge field, which, so far as Montana is concerned, might be considered in the Northern Great Plains province, because it lies east of the Front Range of the Rocky Mountains, but it is also the northern continuation of the Bighorn Basin region of Wyoming, which lies west of the Bighorn Mountains, a range that is generally considered the easternmost range of the Rockies, and for that reason the Red Lodge field is here treated as a part of the Rocky Mountain coal province. The coal of the Bighorn Basin is mostly subbituminous, but that in the lower coal-bearing formation, at the north end of the basin, in the vicinity of Bridger, Mont., is bituminous. The subbituminous coal, however, is of excellent quality, especially that mined at Red Lodge and Bear Creek, at the north end of the basin, and at Gebo, near the south end, and compares favorably with the best subbituminous coal of the Rocky Mountain province.

The coal-bearing rocks outcrop in a narrow belt about the great basin and near the foothills of the surrounding mountains. They dip toward the center of the basin, where, as is indicated on the map, they are deeply covered with other rocks that were deposited later. It is estimated that the coal beds near the center of the basin may lie as much as 10,000 feet below the surface. The irregularity in the thickness of the coal beds and the fact that few railroads have been built within the basin have led to the development of only two mining centers, one at Red Lodge, Mont., in the north end of the basin, and the other at Gebo, Wyo., in the south end of the basin.

The Wind River Basin is of much the same character as the Bighorn Basin, except that the late Tertiary formations more nearly conceal the coal-bearing rocks. For this reason less is known regarding the coal beds, which have been mined in only a small way. The coal is subbituminous and compares favorably with the coal of the same rank in adjacent fields. A little coal has been mined in the vicinity of Hudson. The coal in the middle of the basin lies under thick cover and is probably too deep to be profitably mined.

The Green River region is a great irregular basin in southwestern Wyoming, in which the Rock Springs dome rises like an island in the sea. This region contains, besides the Green River Basin proper, a basin lying between Rock Springs and Rawlins, which extends southward and terminates in a point near Steamboat Springs, Colo. The rocks of this basin include four coal-bearing formations, which are generally well exposed in the upturned rim and in the Rock Springs dome, near the center of the basin. Several kinds of coal occur in the basin, ranging in rank from subbituminous to anthracite. The Tertiary rocks contain subbituminous coal, the Cretaceous rocks subbituminous and bituminous coals, and where these have come in contact with igneous sills, as they have northwest of Steamboat Springs, Colo., anthracite has been formed. The coal at Rock Springs, Wyo., may be regarded as the best type of bituminous coal in this region, and coal of about the same quality occurs along Little Snake River, in Wyoming, and also in the valley of Yampa River, between Hayden and Steamboat Springs, Colo. In the Green River Basin the coal beds are so deeply buried by later formations that it is doubtful whether they can ever be mined. The principal mines are in and about Rock Springs, Wyo., and in the valley of Yampa River below Steamboat Springs, Colo.

This enormous basin, which extends from Rawlins on the east to and beyond Grainger on the west, and from the Wind River Mountains on the north to Yampa River on the south, is one of the largest and most important coal regions in the Rocky Mountain province. It embraces an area of about 17,000 square miles and contains four coal-bearing formations, each of which carries from four to twenty coal beds, ranging in thickness from 2 feet to 20 or 25 feet. It is true that the coal in many areas of this region lies so deep that it may never be worked, but after excluding all such areas it is estimated that at least 6,000 square miles is underlain by coal beds that can be mined when the demand for fuel is sufficient to warrant the expenditure necessary for sinking deep shafts. The quantity of coal in the ground in this region is enormous, probably exceeding that in any other region of similar area in this country. There are only two centers of mining in the Green River region. The most important is Rock Springs, Wyo., on the Union Pacific Railroad, where mining has been carried on since that road was completed in 1869. The other mining center has recently developed in the vicinity of Steamboat Springs, Colo., on the Denver & Salt Lake Railroad ("Moffat road").

West of the Green River Basin is the Hams Fork coal region, which consists of a number of folds of coal-bearing rocks. These extend nearly northward from the southwest corner of Wyoming for a distance of 200 miles. The coal is high-rank bituminous and subbituminous. The coal beds vary considerably in thickness, the largest one of subbituminous rank measuring at one place 84 feet of clear coal. This is the thickest coal bed that has been mined or prospected at the surface in the United States. Somewhat thicker beds have been reported in drill logs in other regions, but the uncertainty of determining the thickness and character of beds penetrated by a churn drill renders such a report of doubtful value. The greatest center of mining is at Kemmerer, Wyo., and this coal is regarded as the best that is produced in the State.

East of the Green River Basin is the Hanna field or basin. This basin lies just back of Laramie Mountain, or the Front Range, and is named for Hanna, Wyo., the principal town and the center of the mining industry. The coals are of low rank, being generally subbituminous but possibly including some bituminous coal that is not yet developed. The character of the coal probably explains the meagerness of the mining operations in this field, as the coal can not hold its own, except for local uses, in competition with the better fuel of Rock Springs, on the west, or some of the Colorado coals, on the south.

South of the Uinta Mountains lies a great, irregular basin-shaped coal region, which is called the Uinta region. It extends eastward and southward from the Wasatch Plateau and terminates in a spoon-shaped point near Crested Butte, Colo. The coal-bearing rocks form the rim of this great troughlike depression. From the rim they dip toward the middle and are there deeply buried by later formations. The coal varies considerably in quality, being best at the two extremities of the region. The coals in the vicinity of Crested Butte have been greatly altered, partly by the mountain-building forces and partly by the volcanic material that has been poured out in this area, and as a consequence some of the coal is high-grade anthracite and some belongs to lower ranks. On the rim, especially to the north, the coal changes within a short distance to subbituminous, and this rank characterizes the coal along the north rim. The coal on the south rim is generally bituminous, and west of Green River it improves rapidly in quality and increases in quantity to Castlegate, Utah, where there are many beds of high-grade bituminous coal, as shown on the map (Pl. I).

The coal beds of the Uinta Basin are not so numerous nor so extensive as those of the Green River Basin, to the north, but even this basin contains an enormous quantity of coal. The area of the basin is about 16,500 square miles, a little less than the area of the Green River Basin, and the part in which the coals are accessible for mining is about 5,750 square miles. The coal beds are most numerous at the two extremities of the region, and naturally those parts contain the greatest quantity of coal. At Newcastle, on Grand River, 109 feet of coal in workable beds has been measured, and the beds at the western extremity are probably just as thick. The thickest bed reported is 40 feet, but beds that measure from 6 to 15 feet are fairly common. The center of mining in the western part of the basin is Castlegate, Utah, where the coal is of excellent quality, and some of it is being coked for use in smelters. The centers of mining in the eastern part of the basin are Crested Butte, where both bituminous coal and anthracite are mined extensively, and Newcastle, on Grand River, a few miles below Glenwood Springs. The coal at Newcastle is generally subbituminous, but a short distance to the south it changes to bituminous and some of it is coked.

The coal-bearing rocks at the west end of the Uinta Basin turn to the south in the Wasatch Plateau, and for convenience of discussion this area is treated as a separate field. The same coal beds that occur in the vicinity of Castlegate, in the Book Cliffs, are found in the cliffs that form the eastern front of the Wasatch Plateau, and the coal is of about the same rank and thickness. The coal beds in the high cliffs that form the east front of the Wasatch Plateau are nearly horizontal and are well exposed in every canyon that cuts this rim. The plateau has a width of about 25 miles, but the coal beds are not exposed along its western margin, because the rocks on that side dip to the west and pass below later formations.

Most of the coal of this field occurs in the Mesaverde formation, but some is found near the base of the Mancos shale. Coal is not generally found in this shale in the Rocky Mountain province, but toward the southwest this lower coal-bearing formation becomes more and more important, and in the next fields to the south it is the principal source of supply.

The Colob and Kaiparowits plateau fields lie at the south end of the Wasatch Plateau, near the south line of Utah. The coals of the Colob Plateau have been examined in considerable detail, but those of the Kaiparowits Plateau are known only from casual inspection and from reports of persons who have traveled through that remote region. The coal of the Colob Plateau occurs near the base of the Mancos shale and is of bituminous rank. It lies high on the plateau and is therefore accessible with considerable difficulty. Its disadvantageous position has not, however, prevented its development, but it has been mined only to supply local needs. A small outlier of the field in Iron County, west of Cedar City, contains anthracite, but the coal is dirty and probably can not compete with the lower-rank but cleaner coals of the Colob Plateau.

The coal in the lower part of the Mancos shale is reported to occur in fairly thick beds in the vicinity of Paria, but no examination has been made to determine their quality or extent. In the Kaiparowits Plateau, northeast of Paria, beds of coal 12 or 15 feet thick have been opened in the face of the cliff and coal has been mined for local use. This coal is in the Mesaverde formation, which probably extends unbroken from the Wasatch Plateau on the north, but in the intervening area it is so covered with lava that the actual connection has never been traced. The quality of this coal has not been determined, but it is probably bituminous and of about the same rank as that in the plateau farther north.

The San Juan River region lies south of the San Juan Mountains, partly in Colorado and partly in New Mexico. It is a great basin-shaped depression with a prolongation running southward through the town of Gallup, on the Santa Fe Railway. Two coal-bearing formations are involved in the folding that produced the basin—the Mesaverde formation at the base and a part of the so-called "Laramie" which has recently been named the Fruitland formation[1] at the top. Both formations are of Upper Cretaceous age; the lower one underlies the entire basin, but the upper is restricted to the part of the basin that lies north and east of Chaco River. The depth of the coal-bearing rocks in the center of the basin has not been determined but is probably several thousand feet. The rocks on the rim of the basin dip toward the center; in the northern part the dip is rather steep, but in the southern part it is so gentle that it can scarcely be detected by the unaided eye.

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[1] Bauer, C. M., Contributions to the geology and paleontology of San Juan County, N. Mex.—1, Stratigraphy of a part of the Chaco River valley: U. S. Geol. Survey Prof. Paper 98, p. 274, 1916.

The coal in the lower formation is generally of better quality than that in the upper formation, but each has felt the effects of the movements that resulted in the upheaval of the San Juan Mountains. The coal is normally subbituminous, but around the north rim the lower coal has been changed by the pressure into bituminous coal that in places is good enough to coke. The upper coal is less altered, but toward the east it also is changed to bituminous coal. South of San Juan River all the coal in both formations is subbituminous except possibly some on the east rim, which has been affected by the uplift of the Nacimiento Mountains. The coal beds of the Mesaverde formation range from 3 to 6 feet or more in thickness wherever they have been mined or prospected, and they are exposed at the surface throughout a wide expanse of country, extending from the rim of the basin north of the Santa Fe Railway on the south to Chaco River on the north and across the entire width of the basin in the other direction. The coal beds of the Fruitland formation, although they contain coal of lower rank, are thicker, especially in the northern part of the basin, where they have a known maximum thickness of 40 feet. Such a bed is exposed in the banks of Animas River below Durango, Colo., but the bed is badly broken by partings which would make mining expensive and detract greatly from the value of the coal.

The north and south sides of the basin have railroad connection, and in these parts the coal is mined, but the mines on the north side are handicapped by having to ship their coal over two mountain ranges and those on the south side have to handle a low-rank fuel, which can not easily compete with coal of a higher rank in near-by fields. Despite these drawbacks and the keen competition of fuel oil, the mines have managed to keep in operation, and the coal meets with a ready though local sale.

The Black Mesa field of Arizona is entirely undeveloped and is therefore largely unknown, except locally. It lies in the Hopi and Navajo Indian reservations and is about 75 miles distant from the nearest railroad point. The coal beds are in the Mancos shale and the Mesaverde formation, both of Upper Cretaceous age. The rocks lie in the shape of a broad, flat basin, forming a plateau upon which some of the Hopi Indian villages are built. The coal is subbituminous but of excellent quality and is used locally for the Indian schools.

Besides the main fields and regions noted above, there are a number of isolated outliers of coal-bearing rocks, mainly in New Mexico and Arizona, that are too small and unimportant to be considered here individually. Some of them, like Los Cerrillos, Carthage, and Capitan, in New Mexico, have been developed to some extent, because they contain coal of a better quality than could be found in many of the larger regions. Thus Los Cerrillos has for many years produced a fine grade of anthracite from a coal bed that has been locally changed by the heat of a sill of igneous rock, and the Carthage field has yielded coking coal. Most of these small fields are comparatively insignificant and will not be described further.

PACIFIC COAST PROVINCE.

The coal in the Pacific Coast province is limited largely to the State of Washington. Both California and Oregon have small fields within their borders, but the coal is generally of low rank or poor quality, and but little mining has been attempted. Washington, on the other hand, is fairly well supplied with coal in the western part, where it is most needed for the various industries that have been developed about Puget Sound. The coal-bearing rocks of Washington have been so greatly folded and contorted and then so deeply covered with glacial drift that it is possible to separate only a few of them into well-marked fields, and according to the local practice they are therefore generally subdivided arbitrarily according to the county in which they occur. The local practice will be followed here.

The coal fields of King County lie on the west side of the Cascade Mountains, extending from tidewater in the vicinity of Renton, 12 miles southeast of Seattle, to the foot of the mountains on the east. The thick cover of glacial drift and the almost impenetrable forest make coal prospecting laborious and difficult except near the principal streams, where these obstructions have been to some extent removed. The coal-bearing rocks are of Eocene (Tertiary) age and correspond in time of deposition with the lignite of the Dakotas, Montana, and Texas. In Washington, however, mountain-building forces have been so active in late Tertiary time that many of the coals have been changed from lignite to subbituminous, bituminous, and even to anthracite. In general, the coals nearest the Cascade Mountains are the most altered. The mountain-building forces not only changed the character of the coal but also folded and broke the rocks in a most intricate manner, so that in places mining is difficult and expensive. The coal beds generally dip at considerable angles and are locally broken and displaced, so that it is difficult to follow a coal bed in mining. The old swamps in which the coal was deposited were apparently subject to many floods, which washed mud and sand in from the surrounding higher lands. These materials settled to the bottom of the swamp, forming a shale or sandstone layer or parting in the coal bed, which to-day detracts greatly from its value, for the shale or sandstone must be removed before the coal can be marketed, and its removal is generally difficult and expensive. If the coal is put on the market after it is simply screened, it will contain a large percentage of ash, which makes it difficult to sell. The lump coal is generally so treated and reaches the market in fairly good condition, but in many places the fine coal is too dirty for marketing and must be washed before it can find purchasers. All coals contain more or less foreign material, in the form of partings or binders, but the coal of Washington includes more of such partings than the coal of many other parts of the United States.

The coals of King County are of subbituminous and bituminous rank in about equal proportions. The best coal in the county, to judge from the heating value of the pure coal, occurs along the mountain front from Snoqualmie on the north to Cumberland, a little south of Palmer Junction, on the south, embracing a belt of country not more than 3 or 4 miles in width. West of this belt lies a similar belt of good coal, which, however, has a lower heating value than that of the belt just mentioned; and then west of all is a belt of indefinite width in which the coal is subbituminous.

Many large mines are developed in this county, especially in the higher-rank coals near the mountain front, but some of the subbituminous coals, owing largely to their position on or near tidewater, are extensively mined, the coal finding a ready market as a domestic fuel.

The coals of Pierce County are the best in the State, but the known productive territory is very much smaller than that in King County. All the coals of this county so far mined or prospected are of bituminous or higher rank. The coal districts may roughly be divided into two groups—(1) the Wilkeson-Carbon Hill and adjacent districts, containing mainly high-grade bituminous coal but also some semibituminous coal, much of which will coke; and (2) the Melmont, Fairfax, and Montezuma districts, containing coal having a fuel ratio ranging from 2½ to more than 6. Thus most of these coals come within the rank of high-class bituminous and semibituminous coal. The coal at Wilkeson is the only coal in the State that has been extensively coked. All these coals bear an excellent reputation in the market.

The coal-bearing rocks in the fields of Pierce County are even more strongly folded and faulted than those of King County, on the north. Many of the coal beds are cut by dikes that ray out from the great volcanic center of Mount Rainier. The coal beds are exposed mainly in the deep canyons cut by Carbon River and its tributaries and consequently have been mined mainly along that stream. The mines are only a short distance from tidewater at Tacoma, with which they are connected by a branch line of the Northern Pacific Railway that was long ago built into this field for the purpose of obtaining fuel for use in locomotives.

All the developed coal of Kittitas County is in the Roslyn field, which is a regular, shallow basin in the vicinity of Cle Elum, in the valley of Yakima River, on the east side of the Cascade Mountains. The basin is not complicated by minor folds and faults, as are those on the west side of the mountains, and hence mining conditions are almost ideal. The coal is a hard, blocky coal of fairly uniform quality, well adapted to shipping and handling. It has been extensively used by the Northern Pacific Railway for locomotive fuel. It is mined by slopes and drifts on the outcrop and by shafts in the middle of the basin.

The coal fields of Thurston and Lewis counties are neither so well known nor so well developed as those of the counties just mentioned, largely because the coal of better rank near the mountains is in many places deeply covered with lava flows, glacial drift, and almost impenetrable forests. The coal in this region near the mountains is of high rank, in many places anthracite, but the complicated folds into which the strata have been bent and the abundance of partings in the coal beds make it impossible to mine the coal at a profit. The developed fields in these counties lie farther from the mountains, along the railroad lines leading from Tacoma, Wash., to Portland, Oreg. The coal beds in this part of the region are comparatively undisturbed and lie in an almost horizontal position. The coal, not having been subjected to the pressures that were exerted farther east when the mountains were uplifted, is of low rank. Those who have examined it most carefully are undecided whether to class it as lignite or subbituminous coal. It lies close to the dividing line between those two ranks and has generally been classed as subbituminous. It contains a large percentage of moisture, slacks badly when exposed to the atmosphere, and is little if any better as a fuel than Texas lignite. The extent of this low-rank coal has not been accurately determined, but it probably extends southward to Columbia River.

The coal fields of Whatcom and Skagit counties are perhaps less extensive than those of the counties so far considered. The coals in these counties range in rank from subbituminous coal at Bellingham to anthracite at Glacier. The anthracite lies in the valley of Glacier Creek northwest of Mount Baker and compares favorably in quality with some of the anthracite of the East. It has not yet been produced on a commercial scale, but mines are being opened, and it may soon be put on the market. High-rank coal has been mined and coked at Blue Canyon, in Whatcom County, and at Cokedale, in Skagit County, but these plants are now abandoned. The oldest mining operation in this region was at Bellingham, where a bed of subbituminous coal 14 feet thick was mined extensively about 30 years ago. On account of the low rank of the coal, the mine was soon abandoned, and now very little coal is mined in either Whatcom County or Skagit County. The rank of the coal, like that of all other coals in this country, decreases away from the mountains.

There are a number of small fields or isolated occurrences of coal in other counties, but they are of little importance and will not be described here.

Only a little coal occurs in Oregon, and that is of poor quality. Mining has been done in a commercial way only in the Coos Bay field, on the coast, in the southern part of the State. The coal in this field is subbituminous and has done little more than to supply the small local demand. Although there is considerable coal in this field, it is difficult to mine, and much of it lies below the waters of the bay. The field is not promising and probably never will be a large producer.

The best coal so far discovered in Oregon is in the Eden Ridge field, in the southern part of Coos County. The rocks are somewhat more disturbed here than in the vicinity of Coos Bay and the coal is of higher rank. It is bituminous, and some of it will coke, but the beds are full of shale partings, which make the coal very dirty. The field has no railroad connection at the present time, and consequently no mining has been undertaken.

Coal has been noted near Medford, in Jackson County; in the Nehalem Valley, in Columbia County, and in other parts of the State, but at none of these places is it of sufficient thickness or purity to be of value.

California, although rich in many other mineral resources, is singularly deficient in coal. At present the lack of coal is not felt, for the State has abundant supplies of fuel oil, but these supplies will sooner or later be consumed, and when the oil is exhausted the problem of obtaining coal will become vital. The only coal field of any prospective importance is that which lies in the Coast Ranges, in San Benito and Monterey counties, and which is known from the places at which the coal has been prospected. The most ambitious attempt to develop this field was made at Stone Canyon, Monterey County, where a bed of coal ranging from 10 to 14 feet in thickness was opened. The attempt was not successful, however, and the mine was abandoned. This coal is of the bituminous rank, and is the only coal of this rank in the State. It is very rich in bituminous matter and is in composition a cannel coal, though it has none of the physical properties of such a coal.

PRODUCTION AND ORIGINAL TONNAGE OF COAL IN THE UNITED STATES.

Although the general description of a coal field is very important to one considering the development of mines, or to one contemplating an investment in mines or in mineral lands, there is another phase of the subject that is of equal if not greater importance to the political economist, and that is the quantity of coal still remaining in the ground, to which future generations may look for their supply of power and heat. As stated in the first part of this introduction, the United States Geological Survey has endeavored to determine this quantity by making estimates of the original tonnage of the various fields, deducting the coal already mined and wasted in mining, and calling the remainder the present and future supply. Such estimates, when first made, were very unsatisfactory, for the data available, even in some of the coal-mining States of the East, were far from adequate for a quantitative statement of this kind, and some of the western coal fields were so little known that only a guess could be made as to their area or tonnage. Nevertheless an estimate was made and published in 1908, in order to meet some of the demands of the time in the discussion of the available resources of the Nation.

The constantly increasing knowledge of the coal fields of the West acquired by the Geological Survey in the course of its regular work of classifying the withdrawn lands and the interest and activity of several State geologists showed clearly that the first estimate of the United States Geological Survey was inadequate and should be revised at an early date. This revision was undertaken in 1912, and the results of the new estimate were published in 1913 as a part of the report on the coal fields of the world made by the Twelfth International Geological Congress. Though this estimate was founded on much more reliable information, and though this information was much more widely applicable to the coal fields of the country, the writer is still conscious of the weak places that of necessity must exist in such an estimate, and he will relish the opportunity to revise the figures at some future time when new information is available, such as will give the estimate an accuracy that it has not heretofore been possible to attain.

In undertaking to make an estimate of the original tonnage of coal in the ground, certain assumptions must be made as a foundation, and the results attained will depend largely upon these assumptions. The three principal assumptions are (1) minimum thickness of bed of the different ranks and grades of coal that can be mined, (2) maximum depth to which mining may be carried in the different ranks of coal, and (3) maximum percentage of ash that may be permitted in the various ranks of coal. As probably no two persons who have attempted to make estimates have made the same basic assumptions, so no two estimates agree as to the tonnage involved. This point is very important and is one that is usually lost sight of by the casual reader, who doubtless wonders why it is that experts disagree so widely in their estimates; whereas if he had analyzed the results a little more closely he might have found that the results were practically in accord.

Most engineers employed by private corporations base their estimates on the present practice of mining and preparing coal for the market, for the mining company must adopt this practice, and manifestly the company will not consider coal minable if it lies at a depth of 4,000 feet while plenty of coal of the same kind is available at a depth not exceeding 1,000 feet. Similarly, it will not consider minable a coal bed 20 inches thick while other beds of coal of the same kind of much greater thickness are still available. Also, to the operator of the present time, 15 per cent of ash in a coal may prevent its sale, and therefore its mining may be impracticable; whereas, if a washery were installed and plenty of water were available, 15 per cent of ash might be no bar to the mining and marketing of the coal. Most of the estimates so far made have been based on present mining conditions and practices, and hence they do not necessarily represent the tonnage that may be regarded as available 10 or even 5 years hence.

In attempting to make estimates of the original coal content of the fields of the United States, the Geological Survey decided that it would be a waste of time and money to attempt to make estimates based on present mining practice, for such estimates would be misleading in that they would not represent the total quantity of coal that undoubtedly would be made available in the future. With this point in mind, it was decided to attempt to estimate the total quantity of coal that ever would be mined in the United States, looking ahead 40, 50, or perhaps even 100 years. Of course, it is not contended that anyone living to-day can say positively what will be done 100 years hence, but an attempt was made to prepare such a forecast. In doing so the present mining practice throughout the world was considered, and the assumptions regarding maximum depth, minimum thickness, and maximum impurity were based upon present practice, but generally the limits now observed were exceeded because it is almost certain that the future will go far beyond the present operations, for in some places to-day the methods are far better than those that generally prevailed 20 or even 10 years ago.

As the deepest coal mines in the world (in Belgium) reach a depth of about 4,000 feet, and as shafts for copper and other metals have been sunk to depths below 5,000 feet, it was thought that future coal mining might be carried to a depth of 6,000 feet; but in order to meet various requirements two limits were set, one at a depth of 3,000 feet, for easily minable coal, and the other at a depth of 6,000 feet, a depth that represents what is now considered the ultimate limit of coal mining. Similarly the minimum thickness of coal bed mined in the United States is about 15 inches; therefore 14 inches was taken as the minimum of high-rank coals for estimating the original tonnage in the several fields. The minimum thickness varies according to the rank of the coal, being approximately 2 feet in subbituminous coal and 3 feet in lignite. The maximum percentage of ash permissible in a coal is more difficult to determine, on account of the variability of the factors involved in the operation of cleaning such coal for the market. Thirty per cent has been regarded as the limit, but it is questionable whether it would not better be placed at 25 per cent.

With the basic factors of the process determined, the actual application of the principle of estimation is an engineering problem, which depends upon the data collected by the geologist and his mapping of the coal fields. For many of the fields these data are fairly sufficient and reasonably accurate estimates have been made, but for other fields the data are confessedly inadequate and the estimates are correspondingly unsatisfactory. The detailed estimates for the fields and States will be given in the chapters devoted to the States, but the accompanying general table shows the estimates by regions and provinces, as such treatment involves in many of the regions parts of several States and hence can be presented only in this introductory statement.

The table shows clearly certain features that are of the greatest interest regarding the distribution and amount of coal in the fields of the United States. It shows first that the great bulk of the coal in this country is low-rank bituminous, lignite, and subbituminous, named in the order of their abundance, and that the high-rank coals are relatively scarce. This is an important point in conservation, as it means that our best coal will be the first to be exhausted and that such exhaustion may occur in the not very distant future. It is also noticeable that the best steaming coal, the semibituminous, is limited practically to the two eastern provinces, and that the exhaustion of this coal will be a greater calamity to the country than the loss of all the anthracite, for coal of this kind has a greater efficiency and is adapted to more diverse uses than anthracite. Most people think of the eastern part of the United States as the greatest repository of coal in the country, and therefore they may be surprised to find that there are two areas in the West that contain a greater quantity. The greatest quantity of coal originally contained in any single area of continuous coal-bearing rocks is 1,202,032,000,000 tons, in the Fort Union region of Montana, Wyoming, and the Dakotas; the second is 665,660,600,000 tons, in the Green River region of Wyoming; and the third is 550,898,800,000 tons, in the Appalachian region of the East.

When the output of the mines is compared with the original quantity available it is seen that the great bulk of our coal is not necessarily coming from the areas that contain the

Eastern p
Anthr
Atlan
Appal

Interior p
North
Weste

Gulf prov

Northern
Fort
Small
Denv
Rato

Rocky M
Smal
Bigh
Gree
Uint
Nort
Sout
Coal
San J
Smal
Idah

Pacific co
Wash
Oreg

43

greatest quantity, but from the areas that contain the best coal. This discrepancy becomes more startling when the production of the individual States is compared with their original coal resources.

Although the relative size of the contents of the coal fields may be a matter of some surprise, the really staggering fact presented in the table is the immense, really inconceivable total quantity of the coal. If all the unmined coal within 3,000 feet of the surface, or 3,538,554,000,000 short tons, could be placed in one great cubical pile as solid as it now lies in the ground the pile would be 18 miles long, 18 miles wide, and 18 miles high. Similarly, if all the coal that has been mined in the United States, plus about 50 per cent for waste, a total of 15,083,100,000 short tons, were piled in the same way, the pile would be 1,540 feet long, 1,540 feet wide, and 1,540 feet high; or, in other words, only about 0.4 per cent of the original amount has been mined or wasted in mining.

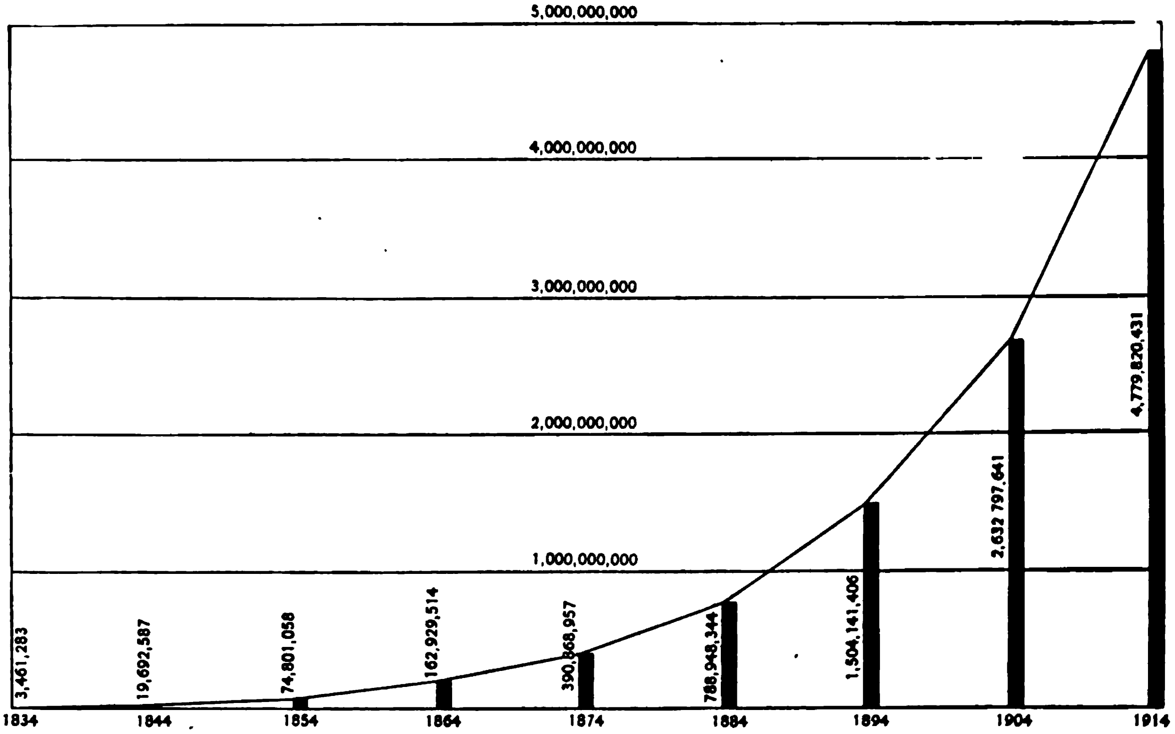

FIGURE 2.—Production of coal in the United States by decades from 1834 to 1914.

There has been considerable speculation regarding the length of time the coal supplies would last, but here again there are so many unknown factors that any estimate partakes of the nature of a guess. Figure 2 represents graphically the coal production in the United States by decades since 1834, and the increasing length of black shows conclusively that our coal production, or consumption, as it may well be called, is growing with great rapidity. In attempting, therefore, to calculate how long the available coal will last it is manifestly incorrect to base the calculation on the present rate of production or consumption, or on the rate for the last decade, as the rate will continue to increase for a long time. If we assume that the rate of consumption will remain the same as it was in 1913, then, after allowance has been made for unpreventable waste in mining and marketing, there will be enough coal to last 4,000 years; but of course such an estimate is absurd, for the rate of 1913 will probably not be held in any single future year.

If the curve shown in figure 2 should be prolonged at its rapidly increasing rate, and if this acceleration should be continued until the coal is completely exhausted, the supply would probably not last 100 years. The true life of our coal fields probably lies between these two extremes, and the probability is that it will be nearer 100 than 4,000 years.

In 1908 Parker[1] attempted to extend the curve of production to what he conceived might be the possible maximum that would ever be reached in this country. His curve, with slight modification to fit recently acquired data, is shown in figure 3. The past and the estimated future production were grouped by decades, beginning with 1835 and extending to the year 2055, when, according to his calculations, the maximum production of 23,000-000,000 short tons would be reached. As the quantity of coal mined in the decade ending with 1914 was 4,779,820,431 short tons, the maximum, according to Parker's figures, would be roughly five times the present production. After the maximum had been reached the production, owing to increased cost of mine haulage, of hoisting from deeper shafts, and of working thinner beds, would gradually decrease, but the decrease would probably be much less rapid than the increase up to the maximum. According to the present estimates there is enough coal in the ground to permit production at this assumed maximum rate for more than 10 decades or 100 years.

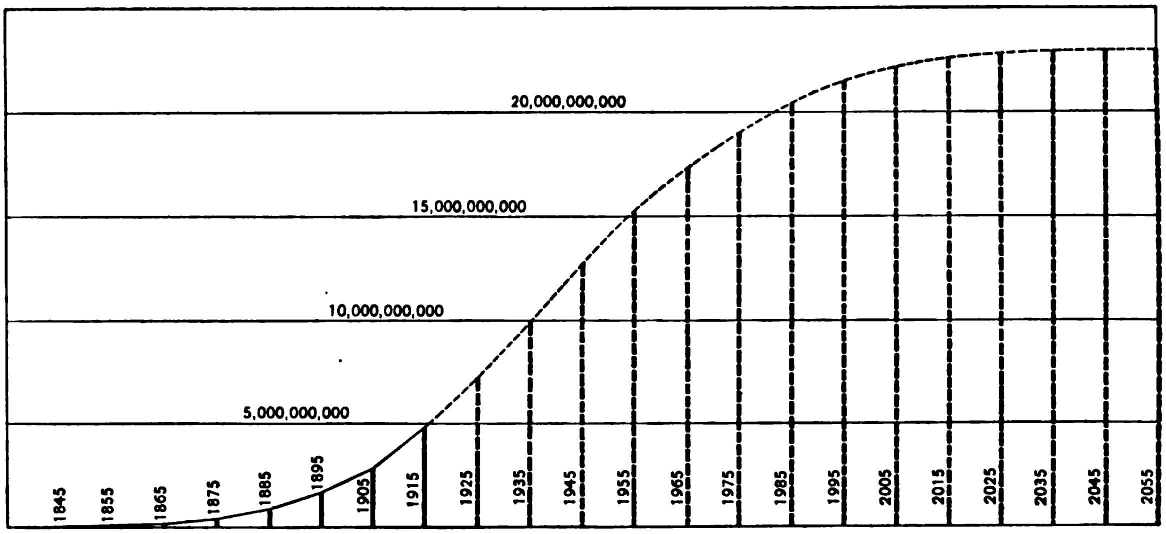

FIGURE 3.—Estimated production of coal in the United States to the year 2055. (After E. W. Parker.)

The figures showing the production since 1908 prove that Parker's curve is too flat, for his estimate of the production in the decade ending in 1915 (4,528,000,000 tons[2]) is nearly equaled by the production of the nine years ending with 1914, which is 4,387,097,796 tons. Thus it seems that his estimated maximum production is too small or that the maximum will be reached before the year 2055. The estimate is probably too small and the maximum production will therefore probably be greater than 23,000,000,000 tons in a decade.

Although by every reasonable estimate the ultimate exhaustion of the coal reserves of the United States appears to be an event so far in the future that it need concern this generation but slightly, the fact must be remembered that the bulk of the coal being mined to-day is the best in the country and that before long, perhaps within 50 years, much of the high-rank coal will be exhausted.

According to the latest estimates[3] the coal reserves of the world, by continents, are as follows:

	Short tons.
Americas	5,627,823,500,000
Asia	1,410,487,600,000
Europe	864,412,600,000
Oceania	187,842,900,000
Africa	63,755,900,000
	8,154,322,500,000

Of the amount contained in the Americas, the United States claims 4,205,154,000,000 tons, or 51 per cent of the total coal of the world. Listed according to coal reserves, the principal coal-producing countries of the world stand as follows:

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[1] Parker, E. W., Past and future coal production in the United States: Mines and Minerals, 1908, pp. 462-465.

[2] The production for the decade ending in 1915 was 4,918,717,283 tons.

[3] The coal resources of the world, an inquiry made upon the initiative of the executive committee of the Twelfth International Geological Congress, Canada, 1913, Morang & Co. (Ltd.), Toronto, Canada.

	Short tons.
United States, including Alaska	4, 231, 352, 000, 000
Canada	1, 360, 535, 000, 000
China	1, 097, 436, 000, 000
Germany	466, 665, 000, 000
Great Britain and Ireland	208, 922, 000, 000
Siberia	191, 667, 000, 000
Australia	182, 510, 000, 000
India	87, 083, 000, 000
Russia in Europe	66, 255, 000, 000
Union of South Africa	61, 949, 000, 000
Austria	59, 387, 000, 000
Colombia	29, 762, 000, 000
Indo-China	22, 048, 000, 000
France	19, 382, 000, 000
Other countries	69, 369, 500, 000
	8, 154, 322, 500, 000

ANALYSES OF REPRESENTATIVE COALS.

In order that the reader may obtain an idea of the comparative value and rank of the coals of the United States, analyses of representative samples are tabulated on the following pages. The figures given are those obtained by the analysis of individual samples of coal, but each sample has been so selected that it represents the average composition of the coal of a certain district or field or the composition of a certain rank of coal.

Most of the analyses given in the table were made by the Bureau of Mines or the United States Geological Survey and so are strictly comparable, but for a few coals, as indicated, such analyses are not available and the figures given are taken from a State report.

The analysis given is that of the sample of coal as it was received at the laboratory. This sample was sealed in an air-tight receptacle immediately after it was cut in the mine, and it reached the laboratory in the same condition as it was in when it was cut in the mine. For this reason the analyses show a larger percentage of moisture than most analyses made for private persons, because the samples so analyzed have not been sealed and the coal has therefore lost some of the moisture it contained when it was in the mine. The Government analyses represent the coal as it leaves the mine and approximately as it reaches the consumer. If the coal is shipped in dry and hot weather some of its moisture may be evaporated; on the other hand, if rain falls on the coal in transit, its original moisture content may be appreciably increased.

The analyses are as follows:

Analyses of representative coals of the United States.

[Unless otherwise specified all analyses were made by the United States Geological Survey or the Bureau of Mines.]

Location and rank of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Heat value (British thermal units).
ALABAMA.						
Lookout Mountain, semibituminous	3. 8	19. 0	64. 4	12. 8	1. 5	12, 980
Blount County, bituminous	3. 4	27. 7	55. 9	13. 0	1. 2	12, 740
Birmingham district, bituminous, coking	2. 4	25. 9	66. 8	4. 9	1. 5	14, 490
Do	2. 3	29. 7	58. 0	10. 0	. 8	13, 490
Birmingham district, bituminous	2. 6	31. 8	62. 9	2. 7	. 8	14, 630
Carbon Hill district, bituminous	4. 7	31. 8	53. 3	10. 2	1. 3	12, 600
Tuscaloosa district, bituminous	1. 6	25. 0	68. 5	4. 9	. 5	14, 700
Cahaba field, bituminous	3. 1	35. 0	55. 8	6. 1	. 4	13, 560
Do	3. 2	31. 0	59. 6	6. 2	1. 2	14, 140
ARIZONA.						
Black Mesa field, subbituminous	9. 9	32. 6	46. 9	10. 6	1. 1	10, 800
ARKANSAS.						
Russellville district, semianthracite	2. 1	9. 8	78. 8	9. 3	1. 7	13, 700
Spadra district, semianthracite	1. 7	10. 5	79. 5	8. 3	2. 5	13, 870
Coal Hill district, semibituminous	1. 4	14. 8	76. 9	6. 9	1. 5	14, 330
Paris district, semibituminous	2. 8	14. 7	73. 4	9. 1	2. 8	13, 770
Jenny Lind district, semibituminous	1. 6	17. 4	73. 1	7. 9	1. 4	14, 160
Huntington district, semibituminous	3. 5	16. 7	72. 0	7. 8	1. 3	14, 020
Camden district, lignite	39. 4	26. 5	24. 4	9. 7	. 5	6, 360

Analyses of representative coals of the United States—Continued.

Location and rank of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Heat value (British thermal units).
CALIFORNIA.						
Stone Canyon district, bituminous	7.0	46.7	40.1	6.2	4.2	12,450
Mount Diablo district, subbituminous	15.0	38.4	34.5	12.1	5.6	9,240
Tesla district, subbituminous	18.0	39.2	26.4	16.4	3.1	8,110
COLORADO.						
Denver field, subbituminous	18.8	30.5	44.5	6.2	.3	9,650
Do	25.6	28.0	41.1	5.3	.4	9,180
Colorado Springs field, subbituminous	26.2	29.7	37.7	6.4	.3	8,350
Canon City field, bituminous	9.1	35.7	48.0	7.2	.9	11,700
Trinidad field, bituminous, coking	2.3	29.8	58.7	9.2	.5	13,780
Trinidad field, bituminous, noncoking	7.8	38.5	44.8	8.9	.5	11,540
North Park field, subbituminous	20.0	32.5	42.5	5.0	.6	9,750
Yampa field, anthracite	7.0	3.4	75.6	14.0	.6	11,740
Yampa field, bituminous	10.4	37.9	45.5	6.2	.4	11,470
Newcastle field, bituminous	7.1	40.8	46.9	5.2	.5	12,620
Newcastle field, bituminous, coking	2.9	33.3	56.7	7.1	.5	13,720
Coal Basin field, semibituminous	2.4	19.4	70.8	7.4	.5	14,380
Crested Butte field, anthracite	3.0	2.9	86.6	7.5	.7	13,500
Crested Butte field, bituminous	5.6	37.6	47.6	9.2	.4	12,430
Grand Junction field, bituminous	7.6	33.6	52.9	5.9	.7	12,440
Durango field, bituminous, coking	2.7	36.1	54.5	6.7	.5	13,910
GEORGIA.						
Manlo district, semibituminous	2.9	17.1	72.2	7.8	.7	14,200
IDAHO.						
St. Anthony field, bituminous	11.5	37.2	47.0	4.3	.5	12,090
Goose Creek field, lignite	34.3	26.6	25.7	13.4	2.5	8,610
ILLINOIS.						
La Salle County, bituminous	13.9	37.3	38.5	10.3	3.4	10,990
Peoria County, bituminous	15.5	34.7	39.8	10.0	2.9	10,740
Fulton County, bituminous	15.7	31.4	43.1	9.8	3.0	10,620
McLean County, bituminous	10.2	35.9	40.1	13.8	2.8	11,150
Logan County, bituminous	14.8	32.9	39.7	12.6	4.0	10,410
Sangamon County, bituminous	14.3	37.2	40.3	8.2	4.4	11,010
Macoupin County, bituminous	13.3	37.1	40.7	8.9	4.1	11,160
Montgomery County, bituminous	12.7	35.5	40.2	11.6	4.2	10,670
Madison and St. Clair counties, bituminous	12.7	36.4	41.4	9.5	3.7	10,990
Marion County, bituminous	10.3	37.4	39.8	12.5	3.7	11,080
Franklin County, bituminous	9.2	33.8	48.6	8.4	.9	11,930
Williamson County, bituminous	8.8	29.9	53.8	7.5	1.1	12,220
Saline County, bituminous	6.0	32.4	54.3	7.3	1.7	12,790
Gallatin County, bituminous	3.4	35.2	52.5	8.9	2.9	13,190
INDIANA.						
Vermilion County, bituminous	10.5	39.5	39.6	10.4	4.0	11,430
Clay County, bituminous, block	15.4	32.6	46.1	5.9	2.0	11,680
Sullivan County, bituminous	13.6	35.0	44.6	6.8	1.1	11,550
Knox County, bituminous	10.6	38.1	43.0	8.3	3.7	11,750
Pike County, bituminous	11.3	38.3	43.5	6.9	3.1	11,920
Warrick County, bituminous	10.4	39.2	42.0	8.4	3.5	11,820
Vandenburgh County, bituminous	9.7	35.6	44.5	10.2	2.9	11,440
IOWA.						
Boone County, bituminous [a]	19.5	33.4	38.3	8.8	5.4	10,520
Polk County, bituminous	14.4	37.8	36.8	11.0	5.9	10,640
Jasper County, bituminous [a]	9.3	39.2	39.1	12.4	2.4	11,210
Marion County, bituminous	15.7	36.9	35.8	11.6	5.1	10,290
Mahaska County, bituminous [a]	14.6	36.3	40.5	8.6	2.9	11,000

[a] Analyses made by the Iowa State University.

Analyses of representative coals of the United States—Continued.

Location and rank of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Heat value British thermal units.
IOWA—continued.						
Lucas County, bituminous	18.7	31.8	41.8	7.7	2.4	10,370
Monroe County, bituminous	13.8	38.9	37.9	9.4	4.7	12,000
Wapello County, bituminous	11.3	38.7	39.5	10.5	4.7	11,850
Taylor County, bituminous [a]	20.2	30.1	38.3	11.4	4.2	10,130
Appanoose County, bituminous	17.1	35.4	40.4	7.1	4.6	10,980
KANSAS.						
Leavenworth County, bituminous	12.0	35.2	39.1	13.7	4.4	10,730
Linn County, bituminous	11.1	28.8	47.5	12.6	2.4	11,230
Crawford County, bituminous	4.9	33.5	52.5	9.1	5.0	12,940
Cherokee County, bituminous	5.1	32.6	53.4	8.9	4.3	12,880
EASTERN KENTUCKY.						
Johnson County, bituminous	6.4	36.2	54.1	3.3	1.2	13,400
Johnson County, bituminous, cannel	2.2	50.6	36.7	10.5	1.0	13,750
Pike County, bituminous	2.8	36.2	56.7	4.3	1.4	14,180
Letcher County, bituminous	2.5	36.5	57.0	4.0	.6	14,150
Perry County, bituminous	3.9	37.2	54.8	4.1	.8	13,730
Laurel County, bituminous	4.5	39.9	50.8	4.8	2.3	13,570
Harlan County, bituminous	4.4	35.0	56.9	3.7	.7	13,920
Bell County, bituminous	2.8	37.8	56.3	3.1	1.0	14,240
Knox County, bituminous	4.2	36.4	53.3	6.1	.8	13,410
WESTERN KENTUCKY.						
Daviess County, bituminous	11.8	36.8	42.0	9.4	3.3	11,150
Ohio County, bituminous	10.0	36.5	44.9	8.6	2.6	11,770
Muhlenberg County, bituminous	8.8	36.2	46.4	8.6	3.6	11,900
Hopkins County, bituminous	8.5	38.0	46.4	7.1	3.5	12,340
Union County, bituminous	3.9	37.1	49.7	9.3	3.5	12,830
MARYLAND.[b]						
Georges Creek basin, semibituminous, high rank	.6	16.6	72.1	10.7	1.3	13,880
Georges Creek basin, semibituminous, medium rank	.6	17.7	73.0	8.7	1.4	14,010
Georges Creek basin, semibituminous, low rank	.7	20.3	70.0	9.0	1.4	14,010
Upper Potomac basin, semibituminous	.9	18.1	71.9	9.1	1.7	14,010
Upper Potomac basin, semibituminous	1.7	19.0	68.1	11.2	1.6	13,450
Castleman basin, semibituminous	2.1	22.0	67.1	8.8	2.3	13,870
Castleman basin, bituminous	.7	24.0	66.8	8.5	1.4	13,970
Upper Youghiogheny basin, bituminous	1.2	23.0	63.9	11.9	2.1	13,260
Lower Youghiogheny basin, bituminous	2.3	25.5	64.4	7.8	1.1	13,780
MICHIGAN.						
Saginaw district, bituminous	11.9	31.5	49.8	6.8	1.2	11,780
MISSOURI.						
Putnam County, bituminous	18.5	32.6	39.0	9.9	4.1	10,040
Harrison County, bituminous	15.3	37.1	40.8	6.8	3.0	10,100
Adair County, bituminous	15.4	34.8	38.8	11.0	3.6	10,460
Grundy County, bituminous	11.7	38.8	38.8	10.7	5.1	11,020
Macon County, bituminous	13.8	34.7	41.8	9.7	3.3	10,960
Randolph County, bituminous	12.1	36.3	42.9	8.7	3.9	11,450
Audrain County, bituminous	10.4	39.3	38.0	12.3	4.9	11,350
Ray County, bituminous	15.8	32.8	41.5	9.9	3.0	10,620
Lafayette County, bituminous	12.3	34.4	42.0	11.3	4.6	11,000
Henry County, bituminous	10.6	37.2	40.7	11.5	3.6	11,250
Bates County, bituminous	7.8	35.5	44.0	12.7	5.2	11,740
Vernon County, bituminous	6.5	32.6	50.8	10.1	5.0	12,460
Barton County, bituminous	5.4	32.1	53.6	8.9	3.6	12,990

[a] Analysis made by the Iowa State University.

[b] Analyses made by the Maryland Geological Survey. Each analysis is the average of all analyses of a certain coal bed in that basin or field.

Analyses of representative coals of the United States—Continued.

Location and rank of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Heat value (British thermal units).
MONTANA.						
Culbertson district, lignite	40.8	25.2	27.8	6.2	0.7	6,150
Glendive district, lignite	34.6	35.3	22.9	7.2	1.1	7,090
Miles City district, subbituminous (?)	29.2	26.2	35.4	9.2	.8	7,670
Havre district, subbituminous	25.6	27.9	39.2	7.3	.6	8,290
Cutbank district, bituminous	6.6	40.3	39.2	13.9	3.1	10,930
Lewistown district, bituminous	8.0	26.6	56.1	9.3	4.4	11,510
Sand Coulee district, bituminous	6.0	28.4	51.4	14.2	2.4	11,150
Roundup district, subbituminous	13.4	32.4	47.6	6.6	.4	11,120
Bridger district, bituminous	9.8	27.6	46.2	16.4	.6	10,240
Bear Creek district, subbituminous	10.7	34.1	46.1	9.1	1.5	10,800
Red Lodge district, subbituminous	11.7	36.1	40.2	12.0	1.1	9,790
Trail Creek field, bituminous	12.4	36.8	42.3	8.5	.6	10,950
Electric field, bituminous, coking	4.0	22.5	59.3	14.2	.6	12,760
Missoula field, lignite	24.7	29.3	26.1	19.9	.9	6,730
NEVADA.						
Esmeralda County, bituminous	2.1	33.7	33.7	30.5	7.2	9,590
NEW MEXICO.						
Raton field, bituminous, coking	2.1	36.1	50.2	11.6	.6	12,970
Los Cerrillos field, anthracite	5.7	2.2	86.1	6.0	.7	13,270
Los Cerrillos field, bituminous	3.2	41.4	44.4	11.0	1.6	12,450
Carthage field, bituminous, coking	3.0	38.0	51.6	7.4	.9	13,260
White Oaks field, bituminous	2.5	37.9	44.9	14.7	.8	12,260
Monero district, bituminous, coking	3.0	39.0	48.3	9.7	3.5	12,930
Gallup district, subbituminous	12.7	36.5	43.3	7.5	.7	11,230
NORTH DAKOTA.						
Ward County, lignite[a]	36.5	28.4	28.7	6.4	1.4	6,750
Mountrail County, lignite[a]	37.8	30.1	24.3	7.8	.6	6,230
Williams County, lignite	41.1	27.2	26.3	5.4	.7	6,490
Northern McLean County, lignite[a]	40.0	29.7	27.1	3.2	.3	6,610
Southern McLean County, lignite	40.5	27.1	27.4	5.0	.8	6,640
Morton County, lignite	38.5	27.6	26.6	7.3	1.3	6,700
Stark County, lignite[a]	40.5	26.3	27.0	6.2	.8	6,210
Billings County, lignite[a]	37.0	26.3	28.7	8.0	1.8	6,590
Adams County, lignite	32.4	30.9	28.1	8.6	1.5	7,330
Bowman County, lignite	41.4	23.9	28.4	6.3	.7	6,240
OHIO.						
Stark County, bituminous[b]	6.7	36.2	48.9	8.2	2.7	12,560
Tuscarawas County, bituminous[b]	4.7	39.2	49.9	6.2	3.3	12,770
Jefferson County, bituminous	4.1	38.5	49.7	7.7	3.7	13,150
Coshocton County, bituminous[b]	4.5	38.7	50.8	6.0	3.6	12,910
Belmont County, bituminous	3.9	43.1	43.9	9.1	4.4	12,840
Guernsey County, bituminous	6.0	34.2	52.0	7.8	2.0	12,720
Noble County, bituminous	3.6	41.5	44.4	10.5	4.9	12,510
Perry County, bituminous[b]	6.7	37.1	49.1	7.1	2.6	12,390
Washington County, bituminous[b]	3.4	37.9	49.1	9.6	5.0	12,750
Hocking County, bituminous[b]	7.5	34.0	52.6	5.9	.8	12,510
Meigs County, bituminous[b]	7.2	32.8	50.7	9.3	1.3	12,000
Jackson County, bituminous[b]	5.3	41.0	45.3	8.4	3.7	12,210
Lawrence County, bituminous	7.1	33.7	50.3	8.9	1.3	12,090
OKLAHOMA.						
Craig County, bituminous	4.1	37.4	48.3	10.2	6.1	12,920
Rogers County, bituminous	4.2	38.2	47.8	9.8	5.2	13,910
Tulsa County, bituminous	6.3	37.7	47.8	8.2	8.2	12,690
Okmulgee County, bituminous	7.5	32.9	51.0	8.6	1.5	12,410
Haskell County, semibituminous	2.7	21.1	69.9	6.3	.8	14,100
Le Flore County, semibituminous	3.1	31.7	58.9	6.3	.9	14,020
Latimer County, bituminous	3.0	36.0	55.9	5.1	1.1	13,710
Pittsburg County, bituminous	3.6	33.4	58.0	5.0	.5	13,740
Coal County, bituminous	6.5	39.0	45.2	9.3	3.7	11,840

[a] Analyses made by North Dakota Geological Survey.

[b] Analyses made by the Ohio Geological Survey.

Analyses of representative coals of the United States—Continued.

Location and rank of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Heat value (British thermal units).
OREGON.						
Coos Bay field, subbituminous	18.0	31.8	39.7	10.5	2.2	8,910
Eden Ridge field, bituminous	12.6	35.0	37.7	14.7	1.3	10,350
PENNSYLVANIA.						
Anthracite region, anthracite	2.8	1.2	88.2	7.8	.9	13,300
Do	2.2	5.7	86.2	5.9	.6	13,830
Sullivan County, semianthracite	3.4	9.3	75.6	11.7	.8	13,120
Tioga County, semibituminous	2.3	20.9	66.9	9.9	1.3	13,620
Elk County, bituminous	2.7	33.7	54.9	8.7	2.9	13,470
Center County, semibituminous	2.9	19.9	69.7	7.5	1.9	14,080
Center County, bituminous	3.5	23.7	61.6	11.2	2.7	13,060
Clearfield County, semibituminous	3.3	19.9	69.0	7.8	2.0	14,020
Clearfield County, bituminous	2.8	24.3	66.3	6.6	.9	14,130
Indiana County, bituminous	1.0	26.1	63.8	9.1	2.7	13,950
Butler County, bituminous	4.6	33.0	54.4	8.0	1.3	13,200
Cambria County, semibituminous, high rank	3.3	12.5	77.9	6.3	1.0	14,340
Cambria County, semibituminous, low rank	2.0	21.2	70.9	5.9	1.2	14,510
Cambria County, bituminous	3.1	26.0	64.4	6.5	1.4	14,160
Westmoreland County, bituminous, coking	2.7	30.4	57.8	9.1	1.3	13,610
Allegheny County, bituminous	3.7	34.0	56.8	5.5	1.4	13,870
Broadtop field, semibituminous	2.1	15.5	76.0	6.4	1.1	14,470
Somerset County, semibituminous, high rank	2.5	12.5	78.8	6.2	1.1	14,380
Somerset County, semibituminous, low rank	2.6	21.5	68.0	7.9	1.7	13,900
Fayette County, bituminous, coking	2.8	30.0	59.8	7.4	1.2	13,990
Washington County, bituminous	1.4	34.6	57.8	6.2	.8	14,240
RHODE ISLAND.						
Portsmouth district, anthracite	13.2	2.6	65.3	18.9	.3	9,310
SOUTH DAKOTA.						
Harding County, lignite	41.5	24.0	24.3	10.2	.6	5,650
TENNESSEE.						
Claiborne and Campbell counties, bituminous	3.6	37.3	55.5	3.6	1.1	13,980
Scott and Fentress counties, bituminous	3.8	38.5	51.2	6.5	1.9	13,400
Anderson County, bituminous	2.2	37.2	54.5	6.1	1.6	13,960
Morgan County, bituminous	2.0	37.5	52.6	7.9	4.0	13,810
Roane and Rhea counties, bituminous, coking	2.2	29.6	59.4	8.8	.5	13,620
Cumberland County, bituminous	4.3	25.7	62.5	7.5	.6	13,630
Overton County, bituminous	3.4	35.6	50.6	10.4	3.1	12,990
White County, bituminous	3.0	39.7	46.9	10.4	4.1	13,950
Hamilton County, bituminous	2.9	29.9	59.2	8.0	1.2	13,760
Bledsoe and Sequatchie counties, bituminous	3.0	29.8	58.9	8.3	1.0	13,560
Grundy County, bituminous	3.6	29.8	57.9	8.7	1.4	13,330
Marion County, bituminous	3.4	28.2	60.1	8.3	.8	13,430
TEXAS.						
Houston County, lignite	33.5	39.5	16.2	10.8	.6	7,140
Wood County, lignite	28.9	35.9	27.3	7.9	.5	8,000
Milam County, lignite	36.0	27.9	28.7	7.4	.8	7,130
UTAH.						
Summit County, subbituminous	14.2	36.0	44.8	5.0	1.4	10,630
Uinta County, bituminous	8.6	36.1	47.2	8.1	1.4	11,580
Grand County, bituminous	7.1	37.0	45.4	10.5	.7	11,720
Carbon County, bituminous	4.4	38.2	50.5	6.9	.8	12,760
Emery County, bituminous	7.2	42.2	44.8	5.8	.7	12,540
Iron and Kane counties, anthracite	8.2	4.4	58.0	29.4	2.3	8,910
Iron and Kane counties, semibituminous	9.5	13.2	49.2	28.1	3.6	8,860
Iron and Kane counties, bituminous	10.4	36.3	43.7	9.6	5.8	10,870

Analyses of representative coals of the United States—Continued.

Location and rank of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Heat value (British thermal units).
VIRGINIA.						
Appalachian region:						
Tazewell County, semibituminous	3.8	15.5	77.8	2.9	0.6	14,860
Buchanan County, semibituminous	2.4	19.6	64.6	13.4	.7	13,160
Buchanan County, bituminous	3.5	31.9	60.9	3.7	1.5	14,390
Dickinson County, bituminous	3.0	32.4	58.4	6.2	1.6	14,030
Russell County, bituminous	2.8	34.9	56.5	5.8	.6	14,150
Wise County, bituminous, coking	2.5	31.7	60.3	5.5	.5	14,250
Lee County, bituminous	3.4	34.4	58.8	3.4	.6	14,130
Montgomery County, semibituminous	1.6	12.3	68.1	18.0	.5	12,340
Richmond Basin, bituminous	2.8	25.7	62.5	9.0	1.4	13,490
WASHINGTON.						
Whatcom County, anthracite	4.4	7.4	76.0	12.2	1.0	12,590
King County:						
Newcastle district, subbituminous	12.1	36.8	40.7	10.4	.3	10,410
Grand Ridge district, subbituminous	15.9	36.0	38.5	9.6	.5	9,970
Snoqualmie district, bituminous	6.1	22.7	58.8	12.4	.9	10,710
Renton district, subbituminous	14.4	36.1	42.0	7.5	.6	10,560
Taylor district, bituminous	5.6	35.9	44.1	14.4	.9	11,550
Ravensdale district, bituminous	7.4	37.4	43.9	11.3	.5	11,500
Black Diamond district, bituminous	6.8	40.0	47.9	5.3	1.4	12,330
Bayne district, bituminous	4.1	32.8	52.8	10.3	.5	12,780
Pierce County:						
Burnett district, bituminous	3.2	35.0	49.3	12.5	.4	12,720
Gale Creek district, bituminous	2.8	33.8	53.9	9.5	1.0	13,450
Wilkeson district, bituminous, coking	2.5	27.7	61.3	8.5	.4	13,890
Wilkeson district, semibituminous	3.6	19.1	61.3	16.0	.5	12,320
Carbon Hill district, bituminous	3.4	32.2	49.5	14.9	.5	12,250
Fairfax district, bituminous	3.6	23.6	59.3	13.5	.4	12,750
Fairfax district, semibituminous	4.0	18.1	58.5	19.4	.5	11,820
Fairfax district, semianthracite	9.2	9.4	63.7	17.7	.7	11,130
Kittitas County:						
Beekman district, bituminous	3.3	34.1	50.5	12.1	.4	12,910
Roslyn district, bituminous	4.7	36.0	46.8	12.5	.4	12,240
Cle Elum district, bituminous	5.0	36.1	46.8	12.1	.4	11,900
Thurston County:						
Centralia district, subbituminous	21.0	33.1	36.7	9.2	.4	8,910
WEST VIRGINIA.						
Wheeling district, bituminous	4.1	36.6	53.3	6.0	2.1	13,400
Moundsville district, bituminous	3.4	41.6	48.0	7.0	3.3	13,310
Fairmont district, bituminous	2.9	34.5	56.9	5.7	.7	14,040
Clarksburg district, bituminous	2.8	38.5	53.1	5.6	2.4	14,110
Upper Potomac basin, semibituminous, high rank	1.1	17.2	73.8	7.9	1.1	14,490
Upper Potomac basin, semibituminous, low rank	1.2	20.4	70.8	7.6	1.0	14,520
Preston County, bituminous	3.6	27.4	62.8	6.2	.9	14,220
Buckhannon district, bituminous	2.5	32.5	56.3	8.7	1.7	13,590
Sutton district, bituminous [a]	2.3	38.3	52.9	6.5	2.1	13,530
Clay district, bituminous	2.8	35.5	54.7	7.0	.8	13,700
Winfield district, bituminous	5.0	39.6	48.3	7.1	1.8	13,000
New River field:						
New River district, semibituminous, high rank	4.0	14.1	73.7	8.2	.8	13,850
New River district, semibituminous, low rank	3.5	22.2	71.9	2.4	.7	14,690
Beckley district, semibituminous, high rank	4.7	13.0	77.9	4.4	.8	14,340
Beckley district, semibituminous, low rank	3.3	18.0	75.6	3.1	.8	14,660
Montgomery district, bituminous	2.4	35.5	56.7	5.4	1.0	14,160
Coalburg district, bituminous	3.4	35.2	53.1	8.3	.7	13,300
Logan district, bituminous	3.3	33.3	58.4	5.0	.7	14,050
Thacker district, bituminous, high rank	3.1	31.4	59.9	5.6	1.2	14,050
Thacker district, bituminous, low rank	4.5	38.8	50.9	5.8	2.0	13,370
Iaeger district, semibituminous	2.0	19.9	70.4	7.7	.7	14,110
Pocahontas field, semibituminous, low rank	3.4	22.5	68.8	5.3	.5	14,370
Widemouth district, semibituminous, medium rank	3.1	18.2	74.8	3.9	.7	14,690
Welch district, semibituminous, high rank	2.8	12.5	80.4	4.3	.7	14,660

[a] Analysis by West Virginia Geological Survey.

Analyses of representative coal of the United States—Continued.

Location and rank of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Heat value (British thermal units).
WYOMING.						
Sheridan district, subbituminous	22.6	32.5	40.4	4.5	0.3	9,220
Bighorn Basin field, subbituminous	16.5	32.9	45.8	4.8	.6	10,750
Black Hills region, bituminous, coking	10.0	39.1	34.3	16.6	4.9	10,250
Glenrock district, subbituminous	21.9	34.0	37.4	6.7	.9	9,070
Hudson district, subbituminous	21.1	31.4	41.7	5.8	.5	9,460
Hanna Basin field, subbituminous	11.5	42.6	39.3	6.6	.4	10,890
Rock Springs field, bituminous	9.8	34.3	52.5	3.4	1.0	12,260
Kemmerer district, bituminous	5.7	37.7	51.3	5.3	1.4	12,580
Kemmerer district, subbituminous	20.6	36.3	40.5	2.6	.5	10,240
Evanston district, subbituminous	14.4	36.8	41.6	7.2	.2	10,440

DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

Professional Paper 100--B

THE COAL FIELDS OF THE UNITED STATES

THE COAL FIELDS OF OHIO

BY

J. A. BOWNOCKER
STATE GEOLOGIST

WITH A COMPUTATION OF THE

ORIGINAL COAL CONTENT OF THE FIELDS

BY

F. R. CLARK

Professional Paper 100, pages 35-96
Published October 29, 1917

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

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THE COAL FIELDS OF OHIO.

By J. A. Bownocker.

INTRODUCTION.

ACKNOWLEDGMENTS.

In preparing this paper the writer made free use of previous publications on the coal and the coal fields of Ohio. Many acknowledgments are made in the text, but the contributions of Dr. Edward Orton and the chemical work of Profs. N. W. Lord and E. E. Somermeier deserve special mention. Prof. F. A. Ray has prepared the map of the Hocking Valley field, which shows for the first time in print the "great fault." He has also prepared a map of the Cambridge field showing its possible extensions to the northeast and a map showing the eastward extension of the Pomeroy field. Dr. C. R. Stauffer has placed at the writer's disposal a section of the Dunkard group, with notes, and Mr. Wilbur Stout has supplied data bearing on the lower coal beds of southern Ohio. Many analyses of coals have been taken from bulletins of the United States Geological Survey and the Bureau of Mines and still others from Bulletin 9 of the Ohio Geological Survey.

LOCATION, EXTENT, AND PRODUCTION.

The coal fields of Ohio lie in the eastern part of the State, extending from near the shore of Lake Erie in Geauga and Lake counties southwestward to Scioto and Lawrence counties, on Ohio River. An area of about 12,600 square miles, nearly one-third of the State, is underlain by coal-bearing rocks. These fields form the western rim of the great Appalachian trough, which extends for 850 miles southwestward from northern Pennsylvania to central Alabama and has a width of about 180 miles in its widest part.

The Ohio fields contain 11 coal beds that are regularly mined for railroad shipment. These beds, named and numbered from the bottom up, are the Sharon (No. 1), Quakertown (No. 2), Upper Mercer (No. 3a), Clarion (No. 4a), Lower Kittanning (No. 5), Middle Kittanning (No. 6), Upper Freeport (No. 7), Mahoning (No. 7a), Pittsburgh (No. 8), Pomeroy (No. 8a), and Meigs Creek (No. 9). Two other beds, the Brookville (No. 4) and Lower Freeport (No. 6a), are regularly mined at some places to supply local demand, and eight others are occasionally mined at favorable places.

The Ohio fields are favored by good shipping facilities, both by rail and river, and lie within easy hauling distance of Lake Erie and of large manufacturing cities. Further, the area is not far from the center of population of the United States. These facts have made Ohio one of the large coal-producing States. In 1915 it ranked fourth in coal mined, and its output was over 6 per cent of the total for the United States. The following figures show the growth and magnitude of the coal-mining industry in Ohio:

Coal mined in Ohio in certain years.

	Short tons.
1838	119,952
1850	640,000
1860	1,265,600
1870	2,527,285
1880	6,008,595
1890	11,494,506
1900	18,988,150
1913	36,200,527
1914	18,843,115
1915	22,434.691

The total coal produced in the State up to the end of 1915 is 723,956,352 short tons, or 6.64 per cent of the total quantity of coal mined to that date in the United States.

TOPOGRAPHY AND ACCESSIBILITY.

The coal-bearing area of Ohio is generally hilly and is most so in the counties that border Ohio River, where hills in places rise 500 feet. During the glacial epoch a great sheet of ice invaded the northern end of the coal fields, planing down the hills and filling the valleys and completely modifying the surface. The ice extended as far south as middle Columbiana, southern Stark, and northern Holmes counties. Consequently the counties of Portage, Mahoning, Columbiana, Stark, Summit, and Medina, lying north of this border, are in places rolling and in places nearly flat.

Numerous streams trench the coal-bearing rocks and along their western border have cut through them and are now at work on the underlying Mississippian formations. The Cuyahoga, Mohican, Walhonding, and Hocking are examples of such streams. Other streams that deeply trench but do not cut through the coal-bearing rocks are Ohio, Tuscarawas, Muskingum, Little Muskingum, and lower Hocking rivers.

The coal outcrops not only at its proper place along the western margin of the coal fields but also in many places in valleys miles east of the margin. The eastward dip of the strata is slight and carries the coal below drainage gradually, so that deep shafting is at present necessary in only a few places. It follows, therefore, that the coal is accessible to an unusual degree in comparison with that of many States.

The coal fields of Ohio are well supplied with railroads, being crossed by several of the large east-west systems and by other roads, which lead directly to the Great Lakes. These main lines, together with their many branches, make accessible almost all parts of this large region. Ohio River, which has trenched its way through the coal fields from Pittsburgh to a point below Ironton, should be one of the great highways for the movement of heavy freight, such as coal, but the shallowness of its water during the summer has prevented the development of such a trade. The Government is, however, engaged in building locks and dams to produce slack water deep enough for navigation, and when all these are completed it is supposed that much of the freight originating in this inland region will reach the coast by Ohio and Mississippi rivers.

GEOLOGIC STRUCTURE.

The coal-bearing rocks of Ohio are part of the great structural trough of the Appalachians. (See Pl. II, in pocket.) The deepest part of this trough is in West Virginia along a line running almost direct from Pittsburgh, Pa., to Huntington, W. Va. Toward this deepest part the rocks dip on both sides, those in Ohio dipping generally southeastward from the outermost limit of the coal fields.

Although the coal-bearing rocks dip generally southeastward at a gentle rate they show many local exceptions, the most prominent of which are due to low folds or anticlines. Orton says:

> There are some points, and especially in eastern Ohio, where the dip rises to 1°, which gives an inclination of 1 foot in 57 feet, or, in other words, about 93 feet to the mile, but the usual limits are between 20 and 40 feet to the mile. Throughout a considerable part of the Hocking Valley, for example, the dip is quite steady at an average of 27 feet to the mile, its direction here being about 65° east of south.

Some of the most marked variations from the monotonous southeastern dip are found in Washington County, especially along Cow and Newell runs. On the bank of Ohio River, a short distance above the mouth of Newell Run, the Cambridge limestone is above drainage level and its vertical displacement, due to the arching of the rocks, is about 600 feet. On Cow Run the rocks form a dome, from whose center the coal dips away in all directions. This arch has raised both the Pittsburgh and Meigs Creek coal beds above drainage over a small area. The Cambridge anticline is one of the most prominent in eastern Ohio and causes the coal beds west of Cambridge to rise instead of dip eastward, as they normally would. Another departure from the normal is found in the southeastern corner of Belmont County, where for several miles a fold lifts the Pittsburgh coal above the beds of Captina Creek. Between Wellsville and East Liverpool is another low arch, but the coal in this locality is thin and the effect of the arch, so far as coal is concerned, is unimportant. The most notable upturning of rocks in the coal measures is near Mineral City, in Tuscarawas County, where the strata at one place are nearly vertical and the effects on the mining of the coal great. Small arches occur in the eastern part of Harrison County (where the Pittsburgh coal occurs), in central Belmont County, and in a few places in counties to the southwest.

THE COAL BEDS.

GENERAL FEATURES.

The coal-bearing rocks of Ohio are all of Carboniferous age and are limited to the upper part of this system. The Carboniferous system, as recognized by the United States Geological Survey, consists of three series, named from above downward, the Permian, Pennsylvanian, and Mississippian. The coal-bearing rocks belong to the Pennsylvanian series and to such part of the Permian series as is present.

The Permian and Pennsylvanian coal-bearing strata of Ohio, like those farther east, are divided into several formations,[1] the Dunkard group ("Upper Barren Coal Measures"), including Greene and Washington formations; the Monongahela formation ("Upper Productive Coal Measures"); the Conemaugh formation ("Lower Barren Coal Measures"); the Allegheny formation ("Lower Productive Coal Measures"); and the Pottsville formation ("Conglomerate group").

Most of these formations, to which Orton assigned an aggregate maximum thickness of 1,700 feet, possess individuality; but the Pottsville and Allegheny grade into each other and the line of their separation is drawn somewhat arbitrarily. The Conemaugh contains a few thin coal beds, only one of which is now worked for railroad shipment and that at a single place. Shale predominates in this formation, but sandstone is common, and several thin beds of fossiliferous limestone occur, notably the Brush Creek, Cambridge, and Ames members, of marine origin. The formation is limited below by the top of the Upper Freeport (No. 7) coal and above by the base of the Pittsburgh (No. 8) coal bed. No formation in the Pennsylvanian is more definitely bounded.

The Monongahela formation has for its basal member the noted Pittsburgh coal bed, which in many places is very prominent on account of its thickness, and in other places is thin and inconspicuous. The upper limit of the formation is marked by the horizon of the Waynesburg coal, the coal itself being generally thin or wanting. The Dunkard group, which includes the highest formations in the geologic column in Ohio, forms the summit of the hills in the southeastern part of the State and is without workable coal beds—workable in this report being applied to beds which are either being mined at the present time or are of a thickness about equal to such beds. In general, the limit of workability at the present time in Ohio is about 2 feet.

COAL BEDS IN THE POTTSVILLE FORMATION.

GENERAL FEATURES.

The Pottsville formation, formerly known as the "Conglomerate group," which according to Orton is 250 feet thick, extends irregularly from Trumbull County southwestward to Scioto County. It is broadest in northern Ohio, where it has a maximum width of approximately 40 miles, and it narrows southwestward to perhaps less than 16 miles. Its basal member is the "Pottsville" or Sharon conglomerate, and its summit is formed by the Homewood sandstone member. Overlying the Homewood is the Brookville coal, which constitutes the basal member of the Allegheny formation. It must be confessed, however, that the upper limit of the Pottsville formation is not sharply marked and that, so far as Ohio is concerned, no very good reason exists for separating it from the overlying Allegheny formation. However, the Ohio geologists have always accepted the classification of Pennsylvania workers, who divided the lower coal measures into two formations, and it seems best to continue that division. The following table shows the sequence of coals and interbedded rocks as given by Orton:

General section of the Pottsville formation in Ohio.

Homewood sandstone.
Tionesta (No. 3b) coal.
Upper Mercer group:
    Ore.
    Limestone.
    Upper Mercer (No. 3a) coal.
Lower Mercer group:
    Ore.
    Limestone.
    Lower Mercer (No. 3) coal.
Upper Massillon sandstone.
Quakertown (No. 2) coal.
Lower Massillon sandstone.
Sharon (No. 1) coal.

SHARON (NO. 1) COAL BED.

The Sharon is the lowest of Ohio coal beds and is workable in only the extreme parts of the coal fields of the State—Massillon and vicinity in Stark County and Jackson and vicinity in Jackson County.

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[1] Prosser, C. S., Ohio Geol. Survey, 4th ser., Bull. 7, p. 4, 1905.

Massillon field.—The Massillon field is by far the larger producer; in fact, were it not for that field the coal would scarcely be noticed in these pages. The area of the Massillon field is, however, small, though it includes parts of four counties. At present the coal is mined for railroad shipment in parts of Lawrence and Tuscarawas townships, Stark County; part of Sugar Creek Township, Wayne County; a small area near Nimisila, a hamlet in Franklin Township, Summit County; and near Deerfield station in the extreme southeast corner of Portage County. However, Lawrence and Tuscarawas townships of Stark County have always been considered the "heart of the bed," and the best of the coal is still found within their borders. East of Tuscarawas River the Sharon coal is nowhere present in the vicinity of Massillon but is found to the north in Summit County. The coal is known in the market as the Massillon coal. In July, 1915, 14 mines had railroad connection. The annual production of the field 15 years ago was about 1,000,000 tons; in 1915 it was about 500,000 tons, and it will continue to decrease year by year until the bed is exhausted. A little prospecting with the drill is occasionally done, but the life of the field will probably not extend much beyond 10 years.

The Geological Survey of Ohio has never mapped this coal for the reason that it does not form or even resemble a continuous bed but consists of a series of basins or pockets whose limits can be determined only by drilling or mining. The largest basin or pocket is said to have had an area of about 300 acres; and at present mines for railroad shipment are opened in basins having no greater area than 10 acres. Many of the basins contain masses of rock, known as horsebacks, whose area may vary from 1 to 5 acres. Commonly the coal bed thins and its quality deteriorates toward the margins of the basins, but in places it ends abruptly. Slope mining is possible in places where the streams have cut through the coal bed, and such mines are easy to drain, but at present nearly all the mining is done through shafts, most of which are less than 200 feet deep.

The coal bed differs from other coal beds of Ohio in being without persistent partings. Some pyrite is present, especially along the borders of the basins or where horsebacks occur. Nevertheless the coal is unusually free from impurities, greatly enhancing the esteem in which it has always been held. The bed, in greatest thickness, measures 4½ to 5 feet, but it changes sharply and may pinch out in a short distance. Two feet is generally the minimum thickness now mined. A variation in thickness from 5 inches to 2 feet 6 inches is shown in figure 4, which represents two sections in Lawrence Township, Stark County. The changes are due to unevenness in both roof and floor, but perhaps more commonly to those in the roof. In places the floor is notably uneven, and the coal may lie on a low swell instead of a flat surface. Shale commonly forms the roof and clay the floor, but in places sandstone forms one or both.

The coal is open burning (that is, it does not fuse during combustion), lustrous, produces a good proportion of lump, and stands transportation well. Films of calcium carbonate known as "white-cap" are common on the surface of the coal and give it a spotted appearance. The coal along the western margin of the field, although good, is not quite up to the highest standard of the bed. The great use of the coal has always been for domestic purposes. It is clean, ignites easily, makes a hot fire, and produces little ash. It contains an average of about 53½ per cent of fixed carbon, 37 per cent of volatile matter, 5½ per cent of moisture, and 4 per cent of ash. Fifteen samples gave an average of 4.2 per cent of ash, two of these showing less than 2 per cent and the highest 6.6 per cent. Cleveland has always been the principal market for the coal.

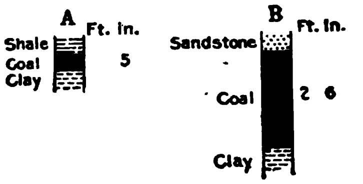

FIGURE 4.—Sections of Sharon (No. 1) coal bed in Lawrence Township, Stark County, northwest of Massillon, Ohio.

Formerly there was, in the Mahoning Valley, a small area of the Sharon coal which bore a fine reputation. It was known as the Mahoning block coal and was used raw in blast furnaces and for domestic purposes. This coal is at present shipped from the Mahoning Valley from only one mine near Lowellville, but it is worked in a small way for local use at other places.

Jackson County.—The other field of Sharon coal lies in Jackson County, in the southern part of the State, but it is smaller and of much less importance than the Massillon field. It is locally known as the Jackson Shaft coal. The coal is at its best in both thickness and quality under the town of Jackson, where it measures 3 to 4 feet. (See fig. 5.) It was discovered in 1863 and is nearly worked out. It is found in scattered hills and ridges west of Jackson, especially in Liberty Township, and is mined for railroad shipment and for use among farmers. Two furnace companies mine the coal for their own use. Wilber Stout estimates that the area of Sharon coal of workable thickness in Jackson County is about 25 square miles but "due to wants, thin places, shaly conditions, and weathered outcrop, not to exceed 50 per cent of this is workable area."

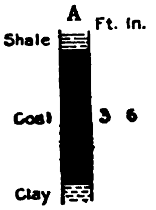

FIGURE 5.—Section of Sharon (No. 1) coal bed, Jackson, Jackson County, Ohio.

A sample of Sharon coal from Decatur mine No. 1, 5 miles west of Jackson, shows on analysis moisture 13.6, volatile matter 31.8, fixed carbon 50.4, ash 4.2, and sulphur 0.86 per cent. Its heat value is 11,680 B. t. u.[1] Other samples from the same general locality show a greater heating capacity, the highest being 14,220 B. t. u.

The coal bed commonly has an uneven floor and hence varies greatly in thickness. It is hard, dry burning,[2] low in ash, very low in sulphur, and is still used raw in the blast furnaces for making pig iron. It is excellent for domestic purposes.

QUAKERTOWN (NO. 2) COAL BED.

The Quakertown (No. 2) coal, known also as the Wellston or Jackson Hill bed, is the second coal in importance in the Pottsville formation. The position of this bed with reference to the Sharon is well shown by the following section, measured by Wilber Stout:

Section in sec. 18, Lick Township, Jackson County, Ohio.

	Ft.	in.
Shale	10	0
Coal, Quakertown, reported thickness	2	6
Covered	24	0
Sandstone, massive	33	0
Covered	5	0
Shale, part covered	22	0
Coal, Sharon, reported thickness	2	8
Covered	2	0
Conglomerate, Sharon	40	0
	141	2

The one known important area of Quakertown coal is in Jackson County (Coal, Washington, and Milton townships), where, according to Orton, it was originally 9 miles long and had a maximum width of 4 miles. The coal was discovered by H. S. Bundy in 1872 in sinking a shaft for the Sharon or Jackson Shaft coal for furnace use. The coal soon proved its value for steam and domestic purposes, and its output grew rapidly, making Jackson County for a time first in coal production in the State. Although coal is obtained from other beds in the county, that derived from the Quakertown is by far the largest, and the variations in output are due largely to the conditions of mining in that bed.

Production in short tons of coal in Jackson County, Ohio.

1885	791,608
1890	836,449
1902	2,412,509
1910	878,656
1913	587,044
1914	532,831
1915	565,309

The maximum output was in 1902 and since that year production has declined notably and will doubtless continue to do so unless other beds in the county are much more extensively worked than they are at present.

Stout says that "The best of the entire field was in the vicinity of Wellston, where the bed had a regular thickness close to 4 feet [see fig. 6] and the coal was of excellent quality." The coal in this area is now exhausted, except for small blocks left in the old mines where the cover is thin or the dip such as to cause trouble from water. Eastward from Wellston the coal bed gradually thins, but no drill records defining this border of the field have been obtained. The largest body of minable Wellston coal at present lies in this area.

The coal is found in workable quantity along the southern border of Washington Township, but farther north, except in secs. 10 and 15, it is of such poor quality as to be worthless or is cut out entirely by sandstone.

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[1] A British thermal unit (B. t. u.) is the quantity of heat required to raise the temperature of 1 pound of water 1° F. at or near 39.1° F., the temperature of maximum density. British thermal units may be reduced to pound calories by multiplying by 0.5556 and to French calories by multiplying by 0.252.

[2] The term dry burning is applied to a coal that does not fuse during combustion and that burns slowly.

Coal Township contained the largest area of the Quakertown coal, nearly its entire surface being underlain by it. Moreover, the thickness reached 4 feet and the quality rivaled the best in the field. However, the coal is practically exhausted.

The coal bed should lie above drainage in southern Lick, eastern Scioto, western Franklin, and eastern Hamilton townships, but it is either wanting or is represented by only a few inches of coal or bony shale. For 25 years efforts have been made with the drill to discover minable coal on the east border of the county and farther east in Vinton County and thus extend the producing territory, but only small areas of good coal, most of the beds thin, have been discovered. The coal usually has an even floor, but in places it forms knolls, over which the bed is thin. The roof is of shale and of good strength.

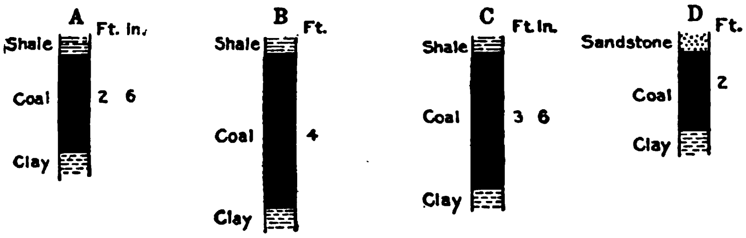

FIGURE 6.—Sections of Quakertown (No. 2) coal bed in Jackson County, Ohio. A, Jackson; B, Wellston; C, Glen Roy; D, Washington Township.

The Wellston coal is fairly tender and does not stand mining and transportation well. It is bright and free from shale or clay except near the roof and floor. Sulphur and ash are low. The coal is open burning. As a domestic coal it is excellent, and it is to be regretted that its use could not have been restricted to that purpose. According to an analysis made by E. E. Somermeier of a sample taken in the Wainwright mine, in sec. 4, Milton Township, the coal shows moisture 9.3, volatile matter 33.0, fixed carbon 54.2, ash 3.5, sulphur 1.25, and nitrogen 1.39 per cent. Its heat value is 12,530 B. t. u.

Within the past few years a pocket of Quakertown coal has been located and mined in Elk Township, Vinton County, a few miles north of McArthur. The coal, where mined, usually ranges from 2 feet 6 inches to 4 feet in thickness. It has a shale roof, clay floor, and is free from impurities. The coal in places has a few inches of cannel and seems to be in all respects first class for domestic purposes. Another small pocket of this coal has been reported in the western part of Hocking County.

MERCER (NOS. 3 AND 3a) COAL BEDS.

General features.—The Lower Mercer (No. 3) and Upper Mercer (No. 3a) coal beds may be easily followed across the State because of the limestones of the same names under which they lie. However, they are not of great value. The Lower Mercer, although mined in a few places for local use, is nowhere worked on a basis for railroad shipment. The Upper Mercer is mined in a larger way in Coshocton County.

Holmes, Mahoning, Tuscarawas, and Stark counties.—The relations of the Mercer to both the overlying and the underlying coals are shown in the following general section for Holmes County by A. A. Wright:

General section of the Mercer coals and the adjacent strata, Holmes County, Ohio.

	Feet.
Coal, Brookville (No. 4).	
Sandstone and shale	20
Coal, Tionesta (No. 3b).	
Sandstone, shaly	20
Limestone, Upper Mercer, thin.	
Coal, Upper Mercer (No. 3a).	
Shale	30
Limestone, Lower Mercer, thin.	
Coal, Lower Mercer.	
Shale	22
Coal (No. 2a).	
Sandstone, Upper Massillon	38
Coal, Quakertown (No. 2).	
Sandstone, Lower Massillon	40
Coal, Sharon (No. 1).	
	170+

The Mercer coals and associated limestones are found in Mahoning County, and both coal beds are in places mined by farmers. The lower bed was once worked in a small way for railroad shipment in this county, and the upper bed has long been a local source of fuel near the village of Canfield. Both coal beds have been mined by farmers in Holmes and Tuscarawas counties, but both are much broken by partings in Holmes County and of little or no importance in Stark County. (See fig. 7.)

Coshocton County.—Western Coshocton County contains the best-known field of Mercer coal in Ohio. The Upper Mercer (No. 3a) coal, here known as the Bedford cannel coal, is workable, according to Orton, over about 1,500 acres. It lies in the northern part of Bedford Township and the adjacent part of Jefferson. The coal has a maximum thickness of 9 feet, not all of which, however, is cannel. Sections show a bed of bituminous coal above the cannel, but its quality is usually not good. (See fig. 8.)

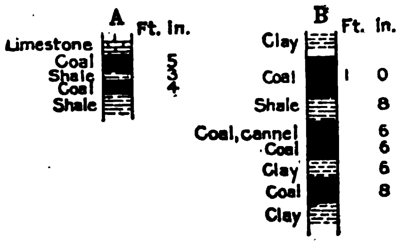

FIGURE 7.—Sections of Lower Mercer (No. 3) coal bed in Ohio. A, Hardy Township, Holmes County; B, Washington Township, Hocking County.

Section of Upper Mercer coal bed in old Mowrie mine, Jefferson Township, Coshocton County, Ohio.

	Feet.
Limestone and flint, Upper Mercer	2
Coal, bituminous, upper part pyritiferous, lower part soft	3
Coal, cannel	5
Clay.	
	10

The cannel is strong and tough and does not disintegrate when exposed to the weather or to transportation.

Muskingum and Licking counties.—Muskingum County has both Mercer coal beds, but here the lower is the more important. It has been mined in a very small way in Hopewell Township in the western part of the county, and just over the line in Licking County it constitutes the well-known Flint Ridge cannel. The coal here is 3 to 4 feet thick and was formerly used for distilling illuminating oil. It contains some layers of shale, which makes it high in ash. Its area is small, and it is worked only for local needs.

Perry, Hocking, and Vinton counties.—Perry and Hocking counties have both coal beds, but it is rare that either attains a thickness of 2 feet. Vinton County makes a little better showing. Near Zaleski the Lower Mercer coal has a good thickness, but it is dirty and can not compete in the market with other coal mined in this county. In Richland Township it is 28 inches thick and is worked by farmers. The Upper Mercer coal has long been mined for local use in the vicinity of McArthur, where it is known as the Newland coal. At its best the bed measures 5 feet, part of which is cannel coal.

Jackson County.—The Lower Mercer coal has been mined by farmers in Hamilton and northern Washington townships, Jackson County, where it measures 24 to 30 inches and is of good quality. The Upper Mercer coal is also found in Jackson County with a thickness of 18 to 30 inches. Jefferson, Lick, and Bloomfield townships have the best beds, but even they are too thin to be of much value.

Scioto County.—In Scioto County the Lower Mercer coal is found in the eastern row of townships, but it does not exceed 24 inches in thickness. The Upper Mercer coal has long been mined for local use in the vicinity of South Webster, Bloom Township, where it is known as the Webster block coal. The bed usually is in two benches separated by a thin layer of clay or shale. The upper bench averages 16 inches in thickness and the lower bench, where present, 6 to 8 inches.

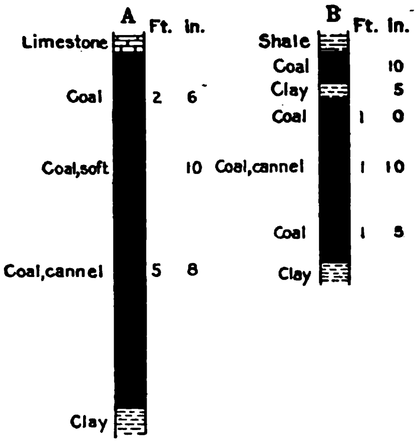

FIGURE 8.—Sections of Upper Mercer (No. 3a) coal bed in Ohio. A, Bedford Township, Licking County; B, Elk Township, Vinton County.

Section of Upper Mercer coal bed on land of John Grant, in sec. 22, Bloom Township, Scioto County, Ohio.

	Ft.	in.
Sandstone, shaly.		
Coal	1	3
Clay, plastic	2	0
Coal		8
Clay, plastic	4	0
	7	11

In mining, the undercutting is made in the clay below the coal, so that none of the fuel is lost. The coal burns with a long flame, owing to its large content of volatile matter, is nonclinkering, and is low in sulphur. It has an excellent reputation for domestic purposes. Near Bloom Junction the coal is a cannel, about 2 feet thick. This is the best-known and best-developed field of the Upper Mercer coal in southern Ohio.

Lawrence County.—Both coal beds are in Lawrence County, but neither is of much value. The Lower Mercer bed attains a thickness of 2 feet in Elizabeth Township and is occasionally mined by farmers. The Upper Mercer coal is mined in Hamilton, Upper, and Elizabeth townships. The section of the coal bed in these townships is similar to that at South Webster (p. 41); the upper bench has a maximum thickness of 2 feet and is of very good quality. The lower bench is about half as thick.

TIONESTA (NO. 3b) COAL BED.

The Tionesta (No. 3b) is the highest coal bed in the Pottsville formation and has the least value. It lies 20 to 30 feet above the Upper Mercer limestone and is rarely of workable thickness even for local use.

Perhaps the best-known field of this coal is in Lawrence Township, Tuscarawas County, where the bed has been mined, off and on, for many years. It is known in that territory as the Bolivar coal. A section, measured by Orton, is as follows:

Section of Tionesta coal bed at Bolivar, Ohio.

	Feet.
Shale, dark.	
Coal, slaty	2
Clay and coal streaks	1
Coal	2
Clay.	
	5

Near Jackson School, sec. 34, Richland Township, Vinton County, the Tionesta coal bed has a maximum thickness of 5 feet, but the coal is bony and high in ash. Shale overlying this coal in Vinton, Jackson, and Scioto counties is usually highly fossiliferous. At Monroe Furnace, Jackson County, the coal is mined for railroad shipment. The bed is about 4 feet thick and consists of two benches separated by an inch of shale. The area underlain by it, however, is small. The coal is mined for local use on Clinton Ridge in Vernon Township, Scioto County, and it has been worked in Decatur and Washington townships, Lawrence County, where its maximum thickness is 3 feet.

COAL BEDS IN THE ALLEGHENY FORMATION.

GENERAL FEATURES.

The Allegheny formation, formerly known as the "Lower Productive Coal Measures," contains the most extensive and valuable coal beds of Ohio. It extends in outcrop from Mahoning to Lawrence County and, as reported by Orton, has a thickness of 250 feet. The Brookville (No. 4) coal is the lowest member of the formation and the Upper Freeport (No. 7) coal is the highest. The formation contains five coal beds that are now mined in a large way, and one of these is of workable thickness above drainage in every county where it is due.

Section of the Allegheny formation at Magnolia in southern Stark County, Ohio.

[By Edward Orton.]

	Ft.	in.
Coal, Upper Freeport (No. 7)	2	0
Clay, shale, sandstone, and concealed	45	0
Sandstone, Lower Freeport,[1] and conglomerate	30	0
Concealed	55	0
Coal, Middle Kittanning (No. 6)	3	0
Clay	3	0
Shale	15	0
Coal	1	6
Shale	1	10
Coal, Lower Kittanning (No. 5)	3	6
Clay	3	0
Shale and sandstone	5	2
Limestone, Putnam Hill	1	8
Coal, Brookville (No. 4)	5	0
	174	8

The Lower Freeport (No. 6a) coal does not appear in the section. It probably lies in the "concealed" mass above the Freeport sandstone member.

Generalized section of the Allegheny formation in Lawrence County, Ohio.

[By Wilber Stout.]

	Ft.	in.
Coal, Upper Freeport (No. 7)	3	0
Shale and sandstone	42	0
Coal, Lower Freeport (No. 6a)	1	0
Shale and sandstone	37	0
Coal, Middle Kittanning (No. 6)	1	4
Shale and sandstone	27	0
Iron ore, Red Kidney		4
Shale and sandstone	3	8
Clay, Oak Hill	3	0

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[1] This is the Freeport sandstone member of United States Geological Survey reports.

	Ft.	in.
Shale	5	0
Coal, Lower Kittanning (No. 5):		
Coal	2	4
Clay		3
Coal		6
Clay	6	0
Shale and sandstone	6	6
Coal		6
Clay, shale, and sandstone	12	0
Iron ore, "Ferriferous"		6
Limestone, Vanport ("Ferriferous")	6	0
Shale, dark	1	0
Coal, Clarion (No. 4a):		
Coal	1	3
Clay shale		7
Coal	1	4
Clay with pyrite		1
Coal	1	0
Sandstone	18	0
Coal, Brookville (No. 4)	2	0
	183	2

BROOKVILLE (NO. 4) COAL BED.

The Brookville (No. 4) coal bed is the basal member of the Allegheny formation. It lies immediately below the Putnam Hill limestone member and for that reason is easily identified. It can readily be traced across the State, but at present it is not an important source of fuel.

Stark County.—The best-known area of the Brookville coal is in Stark County. It is not mined for railroad shipment, though it is used in large quantity for burning lime, for fuel at Canton, and for domestic use in several villages and among the farmers. It is mined a mile southwest of the hamlet of Greentown, in Lake Township, and near New Berlin, where it is used in burning lime. The coal is reported to be 18 inches thick at Middlebranch. It extends practically across the county from north to south, but its width of outcrop is less definitely established. Orton mentions 4 miles, but near the southern border of the county there are workable areas 12 miles apart in an east-west direction. The largest mines are only a mile or two north of Canton, and that city furnishes an excellent market.

Section of Brookville coal bed in mine of Edgefield Coal Co., 2 miles north of Canton, Ohio.

[See fig. 9, A.]

	Ft.	in.
Shale.		
Limestone, Putnam Hill	3	5
Coal, bony, not mined		5
Coal, "top"	2	5
Clay		3
Coal, "bottom"	1	0
Coal, bony, not mined		11
Total section	8	5
Total coal	4	9

A few hundred feet from this section the "top" and "bottom" coal conjointly measure 4 feet 8 inches, but the company counts on only 3 feet 6 inches of good coal. Thin shale or clay partings are not common, but there is considerable pyrite. The coal is reached by a slope, but it lies so near the surface in the surrounding country that much of it has been removed by streams.

South of Canton the Brookville coal is mined in the vicinity of North Industry and Howenstein, and it has been worked in the vicinity of East Sparta. It is used for burning lime, and little or none of it is shipped by rail.

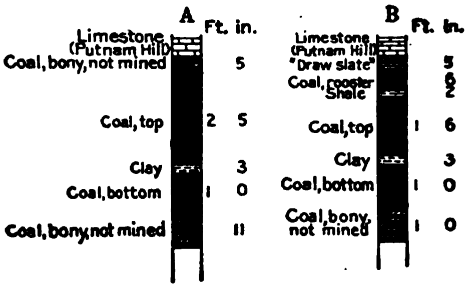

FIGURE 9.—Sections of Brookville (No. 4) coal bed in Stark County, Ohio. A, 2 miles north of Canton; B, 1 mile south of North Industry.

Section of Brookville coal bed in Agricultural & Commercial Lime Co.'s mine, 1 mile south of North Industry, Ohio.

[See fig. 9. B.]

	Ft.	in.
Limestone, Putnam Hill	4	0
"Draw slate"		5
Coal, Brookville:		
Coal, "Rooster," mined		6
Shale		2
Coal, "top"	1	6
Clay		3
Coal, "bottom"	1	0
Coal, bony, not mined	1	0
	8	10

The quantity of the coal in this part of Stark County appears to be large, and though its quality is not first class it does very well for ordinary uses.

Section one-half mile east of Justus, southwest corner of Stark County.

[By Evan Lewis, deputy State mine inspector.]

	Ft.	in.
Mantle rock	15	0
Shale, dark	15	0
Coal, Middle Kittanning (No. 6)	2	6
Clay	3	0
Shale, gray	25	0
Coal, Lower Kittanning (No. 5):		
Coal, bony		6
Clay		4

	Ft.	In.
Coal	2	0
Shale		1
Coal		8
Clay	5	0
Shale, gray	30	0
Limestone	3	0
Coal, Brookville (No. 4) (fig. 10, A):		
Coal		2
Shale		1
Coal	2	3
Clay		6
Coal	2	0
Shale	1	4
Clay	5	0
Shale, gray	15	0
Coal, Upper Mercer (No. 3a):		
Coal, bony		10
Coal	2	2
Clay	4	0
	135	5

The Lower Kittanning and Brookville coals are mined at this place, and plans are being made to work the Upper Mercer at an early date.

Tuscarawas and Coshocton counties.—The Brookville coal is commonly thin and unimportant in Tuscarawas County. In western Coshocton County it thickens and is an important source of fuel among the farmers in Jefferson, Bedford, and Newcastle townships, where it reaches a maximum thickness of 4 feet. The following section is reported by Orton:

Section of Brookville coal bed in Moore's mine, Jefferson Township, Coshocton County, Ohio.

	Ft.	In.
Limestone, Putnam Hill.		
Shale, false roof		2
Coal		8
Shale		1
Coal	2	0
Shale		3
Coal		8
Clay.		
	3	10

The coal is at least of fair quality and by some is preferred to the cannel coal of the vicinity.

Muskingum, Perry, and Hocking counties.—The Brookville coal is found in the western portion of Muskingum County, but here it is less than 3 feet thick and hence is of little importance. Years ago a small mine was opened in this bed at Zanesville. The coal is found in Perry and Hocking counties, but it is thin and not mined.

Vinton County.—The Brookville coal attains workable thickness in Vinton County, where it has long been mined in Elk, Swan, Madison, and Clinton townships under the name Winter's coal or "Flint vein," the latter name being given because of the presence in places of a bed of flint between the two benches of coal. This coal varies considerably in thickness in this vicinity, as is shown by the following section and also by figure 10, B.

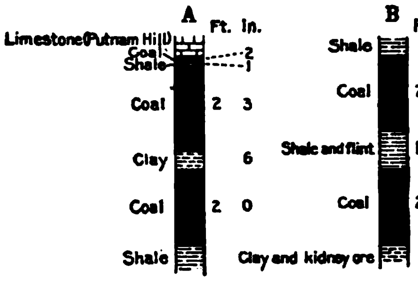

FIGURE 10.—Sections of Brookville (No. 4) coal bed in Ohio. A, Justus, Stark County; B, McArthur, Vinton County.

Section of Brookville coal bed at McArthur, Ohio.

	Ft.	In.
Shale.		
Coal	2	0
Shale		3
Coal	2	0
Clay and kidney ore.		
	4	3

The coal was formerly worked at Zaleski for railroad shipment, but the mine was abandoned years ago. The coal varies considerably from place to place but is of fair quality for steam and domestic purposes.

Jackson County.—The Brookville coal is mined in a small way for railroad shipment in Milton Township, Jackson County.

Section of Brookville coal bed in mine of Minglewood Coal Co., sec. 24, Milton Township, Jackson County, Ohio.

	Ft.	In.
Coal	2	0
Clay		1
Coal		8
Shale, gray	1	4
Iron ore		2
Shale, gray		3
Coal		6
	5	0

An analysis of the top layer of this coal shows 6.1 per cent of ash, 2 per cent of sulphur, and a heating value of 12,560 B. t. u.

Farther south in Jackson County the coal bed thins and has little or no value.

Lawrence County.—The coal is found in Lawrence County, but it is thin and has never been worked except in the smallest way.

CLARION (NO. 4a) COAL BED.

General features.—The Clarion (No. 4a) coal bed is easily recognized by its position under the Vanport or "Ferriferous" limestone, and for that reason it is often known as the "limestone coal." The coal is open burning, moderately hard, and in northern Ohio it is in places a cannel. It contains shale or clay impurities, and hence is high in ash; sulphur content also is large. However, the coal is suitable for steam and domestic purposes, and the day is not far distant when it will be eagerly sought. The coal bed in southern Ohio is nearly always divided into three benches by shale or clay partings whose thickness ranges from less than 1 inch to a foot. In northern Ohio it is a solid bed without definite partings.

Although the coal can be easily traced across the State, it is not of value except in the two opposite parts, northeastern Ohio and the extreme southern part of the State.

Columbiana County.—In Columbiana County the coal is mined in places. In the valley of North Fork of Little Beaver Creek, about a mile below Lisbon, the coal ranges from 2 feet 8 inches to 3 feet 4 inches in thickness, and contains some layers of shale or pyrite. It is used for domestic and steaming purposes. A dark brittle limestone, which lies 5 to 7 feet above the coal has been designated the "Ferriferous." The following is Orton's section, slightly changed, of the strata in the vicinity of Lisbon:

Section of the strata in the vicinity of Lisbon, Ohio.

	Ft.	in.
Coal, Upper Freeport (No. 7)	3	4
Clay	2	0
Limestone, Upper Freeport	2	0
Unseen	23	0
Sandstone	20	0
Coal, Lower Freeport (No. 6a)	1	0
Shale	7	0
Limestone, Lower Freeport	5	0
Sandstone, Freeport, and shale	50	0
Coal, Middle Kittanning (No. 6)		8
Sandstone	12	0
Coal, Lower Kittanning (No. 5)	1	4
Shale	37	0
Limestone, Vanport ("Ferriferous")	3	0
Coal, Clarion	3	0
Clay	4	6
Coal	1	6
	176	4

The Clarion coal is mined in the northern part of Columbiana County and is shipped from the Delmore mine, 1½ miles west of Leetonia. The following section was measured in this mine:

Section of Clarion coal bed in Delmore mine, 1½ miles west of Leetonia, Ohio.

	Ft.	in.
Shale.		
Coal	3	1
Shale, hard	1	3
Coal		9
Clay	12	0
	17	1

The coal has no regular partings, but shale and pyrite bands are not uncommon. The product of the mine is used largely for locomotives. The bench below the hard shale is not mined. It is reported to range from 6 to 12 inches in thickness but in places to be wanting. The Lower Kittanning or No. 5 coal was formerly mined in this vicinity.

The Clarion coal has long been mined in the vicinity of Canfield, Mahoning County, where it is a cannel and was formerly distilled for illuminating oil. Newberry says:

> It is a very variable seam so far as regards thickness and character but is almost always present in one or another of its phases at the horizon where it belongs. In some localities it is 6 feet in thickness, all cannel coal of good quality; in others it is a remarkably pure bituminous coal 2½ to 3 feet thick, while more generally it is found to have a thickness of about 3 feet, of which 6 to 10 inches of the upper part is cannel.

This coal bed has never been mapped in Columbiana and Mahoning counties, but it appears to occupy a large area and may be looked on as a reserve that will be eagerly sought when the thicker coal beds are a thing of the past.

The Clarion coal can be followed in outcrop from Columbiana County southwest to Vinton, where it again attains workable thickness. Between these distant counties the coal rarely if ever measures 2 feet in thickness and generally is represented by only a streak.

Lawrence County.—The one important field of the Clarion coal lies in Lawrence, Scioto, Jackson, and Vinton counties, where it is worked for railroad shipment as well as for local purposes. For many years the Wellston or Quakertown bed was mined because of its superior quality, and the Clarion bed was neglected, but the increasing demand for fuel and the scarcity of Wellston coal led to mining in the Clarion, which has now grown to considerable importance. With the exhaustion of the better coal the Clarion will be more and more in demand.

The coal is above drainage in the western half of Lawrence County and is exposed in numerous places, especially in the northern part. The Vanport ("Ferriferous") limestone is well developed there, and by its aid the identification of the coal is easy.

Section of Clarion coal bed from mine of J. R. Edwards, sec. 23, Washington Township, Lawrence County, Ohio.

[See fig. 11, B.]

Limestone, Vanport ("Ferriferous").	Ft.	in.
Coal, upper bench	1	0
Shale		5
Coal, middle bench	1	6
Shale		2
Coal, lower bench		6
Clay.		
	3	7

The section shows only 3 feet of coal, but others in the county (see fig. 11, A) show as much as 4 feet 4 inches.

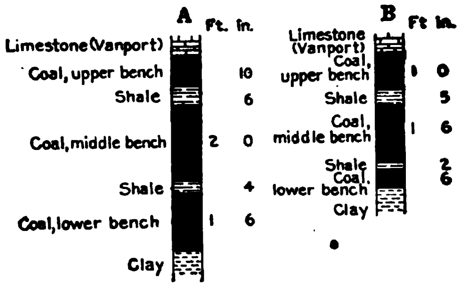

FIGURE 11.—Sections of Clarion (No. 4a) coal bed in Lawrence County, Ohio. A, Decatur Township; B, Washington Township.

The proximate analysis of a sample from this mine gives moisture 6.0, volatile matter 39.1, fixed carbon 43.0, and ash 11.9 per cent. The ultimate analysis gives carbon 63.32, hydrogen 5.26, oxygen 13.24, nitrogen 1.22, sulphur 5.10, and ash 11.86 per cent. The heating value is 11,730 B. t. u.

Scioto County.—In Scioto County the Clarion coal is limited to Bloom Township and is worked for railroad shipment in a single mine. The coal is similar in all respects to that in Lawrence County.

Jackson County.—Jackson County contains a large area of Clarion coal in its eastern tier of townships, Madison, Bloomfield, and Milton, and in each of these the coal is mined for railroad shipment as well as for use by farmers.

Section of Clarion coal bed in Pittinger mine, Wellston, Jackson County, Ohio.

[See fig. 12, A.]

	Ft.	in.
Coal, upper bench		11½
Shale		9
Coal, middle bench	1	4
Shale		1½
Coal, lower bench	1	2
Clay.		
	4	4

The proximate analysis of a sample from this mine shows moisture 5.3, volatile matter 41.0, fixed carbon 45.3, and ash 8.4 per cent. An ultimate analysis of the same sample gave carbon 66.52, hydrogen 5.50, oxygen 14.58, nitrogen 1.28, sulphur 3.72, and ash 8.40 per cent. The heating value is 12,290 B. t. u.

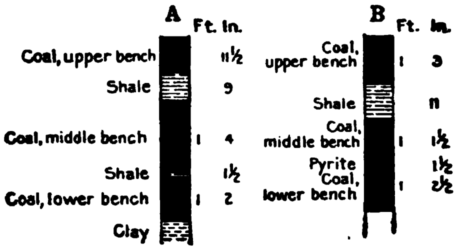

FIGURE 12.—Sections of Clarion (No. 4a) coal bed in Ohio. A, Wellston, Jackson County; B, Wilkesville, Vinton County.

Vinton County.—Vinton County is the third source of Clarion coal, but the known workable areas are restricted to Wilkesville and Vinton townships, where it is mined and shipped on the Hocking Valley Railway. The limestone and coal are well exposed along Raccoon Creek, but east of this stream the coal in a short distance dips below drainage level.

Section of Clarion coal bed in Lawler mine, Minerton, Vinton County, Ohio.

	Ft.	in.
Coal, upper bench	1	6½
Shale		6½
Coal, middle bench	1	2
Shale		1½
Coal, lower bench, including a pyrite band near bottom	1	1
Clay.		
	4	5½

The proximate analysis of a sample from this mine shows moisture 4.5, volatile matter 40.1, fixed carbon 46.5, and ash 8.9 per cent; the ultimate analysis shows carbon 67.17, hydrogen 5.44, oxygen 13.03, nitrogen 1.28, sulphur 4.23, and ash 8.85 per cent. The heating value is 12,430 B. t. u. The character of the coal bed at Wilkesville is shown by figure 12, B.

LOWER KITTANNING (NO. 5) COAL BED.

General features.—The Lower Kittanning (No. 5) coal bed may readily be traced across the State from Columbiana County to Lawrence County. However, it is not everywhere of minable thickness according to present standards, and in fact is not now one of the largest sources of coal in Ohio. The general group of beds of which it is a part is one of great value, for a short distance below it lies the Vanport or "Ferriferous" limestone and ore, the former used in making Portland cement and the latter a source of iron for blast furnaces years ago. More important by far, however, than these is the great bed of clay that directly underlies the coal and that is so extensively used in the clay industries of eastern Ohio. About 25 feet above the Lower Kittanning coal lies the Middle Kittanning bed, and this is one of the two most important coals in Ohio, its only rival being the Pittsburgh bed. Between the two Kittanning coal beds there is found in places a bed of clay or shale that is suitable for the manufacture of clay wares. The sequence of these beds is as follows:

General sequence of the Middle and Lower Kittanning coal beds and underlying strata in Ohio.

Middle Kittanning (No. 6) coal.
Middle Kittanning clay.
Shale or sandstone.
Lower Kittanning (No. 5) coal.
Lower Kittanning clay.
"Ferriferous" iron ore.
Vanport ("Ferriferous") limestone.

Columbiana County.—The Lower Kittanning coal was formerly mined in a large way at Leetonia, Columbiana County, and was used for making coke for local blast furnaces. The following is Orton's section and comment on the coal at this place:

Section of Lower Kittanning coal bed at Leetonia, Ohio.

	Ft.	in.
Shale with kidneys and plates of iron ore	8	0
Coal		8
Parting		
Coal	1	8
Clay	2	6
	12	10+

The coal is found in two benches, the lower of which is much the purer. The upper bench often becomes slaty and cannel-like, and must then be rejected. The bottom coal, which is also called the Smith coal, is a cementing coal of pronounced character, but the upper bench never has this quality. * * * The bottom coal is also an exceptionally good fuel for rolling mill use. It burns with a bright blaze and gives out its heat quickly.

The area of the Leetonia field is small and the coal has not been mined for years except locally for domestic purposes. When the field was visited in 1915 not a mine was in operation, though one was being opened for local use near Washingtonville, where the section given in figure 13, A, was measured.

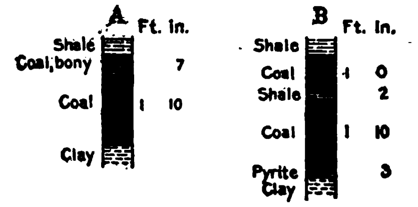

FIGURE 13.—Sections of Lower Kittanning (No. 5) coal bed in Ohio. A, Washingtonville, Columbiana County; B, Pike Township, Stark County.

Carroll, Stark, and Tuscarawas counties.—From Columbiana County the Lower Kittanning coal can be followed southwest through Stark and Carroll counties into the adjacent corner of Tuscarawas County. In Pike Township, Stark County, it has the thickness and character shown in figure 13, B. It is worked along Big Sandy Creek in the northwest corner of Carroll County, and it constitutes the well-known Mineral City bed in Tuscarawas County.

Section of Lower Kittanning coal bed from Huff Run mine No. 1, Mineral City, Ohio.

[See fig. 14, A.]

	Ft.	in.
Shale, dark.		
Coal		8
Coal, bony		⅜
Coal		1½
"Soot"		¼
Coal	1	1
Pyrite		¼
Coal		4¼
"Soot"		½
Coal		4½
Coal, bony		½
Coal		9¼
Clay.		
	3	6⅜

The proximate analysis of a sample from this mine gave moisture 5.3, volatile matter

38.7, fixed carbon 48.3, and ash 7.7 per cent; the ultimate analysis gave carbon 69.75, hydrogen 5.46, oxygen 12.65, nitrogen 1.18, sulphur 3.25, and ash 7.71 per cent. The heating value is 12,900 B. t. u.

The rocks in the vicinity of Mineral City have been disturbed by crustal movements and form a prominent syncline, which of course has its effect on mining. Orton says: "There is no known portion of the coal field of Ohio where there has been a tithe of the disturbance that occurs in the vicinity of Mineral Point [Mineral City]."

The coal is mined by stripping for railroad shipment on the Hagg farm in Sandy Township, 2½ miles east of Sandyville, where the thickness ranges from 4 to 5 feet and the structure of the bed is similar to that recorded in the preceding section. The coal in this part of Tuscarawas County manifestly contains some impurity, but its heating value is good, and it ranks well as a steam producer. It is extensively used in burning clay wares. From Sandy Township the Lower Kittanning coal can be followed southwest across the county. It has been mined in both large and small ways between Mineral City and Canal Dover, but southwest from Canal Dover it is thin and has little value. The coal is of little or no importance in Holmes and Coshocton counties.

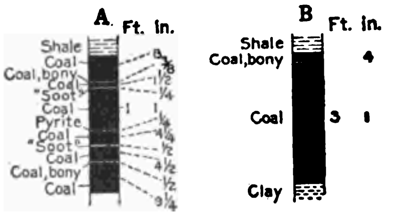

FIGURE 14.—Sections of Lower Kittanning (No. 5) coal bed in Ohio. A, Mineral City, Tuscarawas County; B, Toronto, Jefferson County.

The lower Kittanning coal is also mined in a small way in the bluffs of Ohio River in Jefferson County. A section of the bed at Toronto is represented in figure 14, B.

Guernsey County.—In Guernsey County the Lower Kittanning coal is found in the valley of Wills Creek for several miles south of Kimbolton and is reported to have a thickness as great as 4 feet 9 inches.

Muskingum County.—The Lower Kittanning coal is not of great importance in Muskingum County and as far as now known is of workable thickness in only two areas, the vicinity of Zanesville and Newton Township. The Zanesville area is small and the coal is known as the "4-foot bed." It has long been used at Zanesville for domestic and other purposes and is rated as a good fuel.

Section of Lower Kittanning coal bed in old Harper mine near Zanesville, Ohio.

	Ft.	in.
Coal	1	0
Parting		2
Coal	2	0
Shale		1
Coal	1	0
	4	3

Newton Township forms the southwestern corner of Muskingum County, and the Lower Kittanning coal is there of importance.

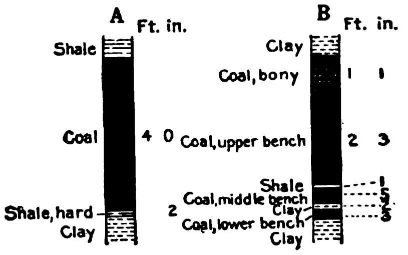

FIGURE 15.—Sections of Lower Kittanning (No. 5) coal bed in Ohio. A, Redfield, Perry County; B, Milton Township, Jackson County.

Perry County.—The coal extends from Muskingum into northeastern Perry County, where it is mined at Redfield (fig. 15, A) and a mile or two east of New Lexington for railroad shipment and for local use, and is locally known as the Lower New Lexington or 4-foot bed. The coal in places is without partings and may be free from dirt, but the floor rises and falls, causing the thickness of the bed to vary.

Section of Lower Kittanning coal bed in Copelin mine, sec. 2, Pike Township, Perry County, Ohio.

	Ft.	in.
Shale.		
Coal, upper bench		6
Coal, horn [1]		1
Coal, middle bench	1	0
Parting		½
Coal, lower bench	1	9
Clay.		
	3	4½

The proximate analysis of a sample from this mine gave moisture 6.8, volatile matter 35.2, fixed carbon 47.8, and ash 10.2 per cent; an ultimate analysis gave carbon 64.78, hydrogen 5.26, oxygen 13.86, nitrogen 1.22, sulphur 4.72, and ash 10.16 per cent. The heating value is 11,860 B. t. u.

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[1] The term "horn coal" here means an impure cannel but is used by some to designate any lean, impure coal or bone.

The coal underlies the southern townships of the county and has been mined for local use at several places. Perry County contains a large acreage of the Lower Kittanning coal of suitable thickness and quality for mining in a large way, but its development has been retarded by the presence of the Middle Kittanning bed, which is thicker and generally more desirable.

Hocking, Vinton, and Jackson counties.—The Lower Kittanning coal is thinner and of smaller value in Hocking County and still less so in Vinton County, but it thickens in eastern Jackson County, where it is mined in a small way for railroad shipment. The bed is irregular but ranges from 3 to 4 feet in thickness over hundreds, perhaps thousands of acres. A section of the coal bed in Milton Township is represented in figure 15, B.

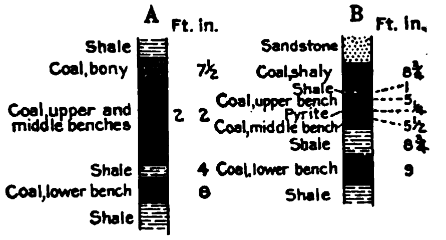


FIGURE 16.—Sections of Lower Kittanning (No. 5) coal bed in Lawrence County, Ohio. A, Etna, Elizabeth Township; B, Coalgrove, Perry Township.

Lawrence County.—The coal is still more valuable in Lawrence County, across which it can be readily traced to Ohio River, in whose bluff it is mined at Coalgrove. A section of the coal bed at this place is shown in figure 16, B. It is worked in Washington, Decatur, Elizabeth, Upper, and Perry townships. It is rated at its best in Elizabeth Township.

Section of Lower Kittanning coal in Hocking Coal Co.'s mine No. 2, Ætna station, Elizabeth Township, Lawrence County, Ohio.

[See fig. 16, A.]

	Ft.	in.
Shale.		
Coal, bony		7½
Coal, upper and middle benches	2	2
Shale, gray		4
Coal, lower bench		8
Shale.		
	3	9½

The proximate analysis of a sample from this mine shows moisture 8.1, volatile matter 34.5, fixed carbon 47.7, and ash 9.7 per cent; an ultimate analysis gives carbon 65.54, hydrogen 5.44, oxygen 15.95, nitrogen 1.23, sulphur 2.13, and ash 9.71 per cent. The heat value is 11,930 B. t. u.

The coal is open burning, rather soft, moderate in ash and sulphur. It makes a fair coke but is not used for that purpose. It is well adapted for steam and domestic uses and is the main reliance of the city of Ironton. The field is the most valuable one of this bed in Ohio, and the coal is extensively mined for railroad shipment.

MIDDLE KITTANNING (NO. 6) COAL BED.

The Middle Kittanning (No. 6) coal, on account of its quantity and quality, is the most valuable in Ohio. It is found along the State line in Columbiana County and can not only be followed with ease across the State to Lawrence County on Ohio River but it is workable in every county where it should appear above drainage and in most of them on a large scale. The bed lies 20 to 35 feet above the Lower Kittanning coal and is generally easily identified.

Columbiana County.—The Middle Kittanning coal underlies much of the eastern and southern parts of Columbiana County, and its relations to lower beds are well shown in the following section measured by Orton:

Section at Robbinsville, Ohio.

	Ft.	in.
Sandstone, Freeport ("Lower Freeport")	20	0
Coal, Middle Kittanning (No. 6)		8
Sandstone and shale	15	0
Coal, Lower Kittanning (No. 5)	1	4
Shale and ore nodules	40	0
"Draw slate"	1	0
Coal, Clarion (No. 4a)	3	0
Clay	4	0
Coal	1	8
	86	8

The coal bed in Columbiana County is less than 3 feet thick and has not been worked in a large way, but it has been mined for local use in Dry Run near East Liverpool. The coal is clean, of good quality, mines with much lump, and has an excellent reputation.

Section of Middle Kittanning coal bed at mouth of Dry Run, Columbiana County, Ohio.

[See fig. 17, A.]

	Ft.	in.
Shale.		
Coal, impure		4
Coal	1	6
Shale		3
Coal, impure		4
Clay.		
	2	5

A sample taken at this place showed 4.6 per cent ash, 1.76 per cent sulphur, and has a heating value of 14,020 B. t. u., which compares favorably with that of the best coals mined in Ohio.

Along Yellow Creek in the southern part of the county the Middle Kittanning coal has also been mined and is there known as the Hammondsville strip vein. It is thin and can not compete with large beds.

Stark County.—The Middle Kittanning coal extends from Columbiana County west into Stark, where it has workable thickness in the eastern and southern townships. At Waynesburg, in the southeast corner of Sandy Township, the bed has the following structure:

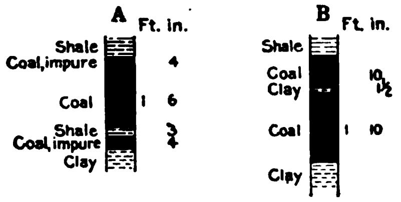


FIGURE 17.—Sections of Middle Kittanning (No. 6) coal bed in Ohio. A, East Liverpool, Columbiana County; B, Nimishillen Township, Stark County.

Section of Middle Kittanning coal bed in mine of Whitacre Fire-proofing Co., Waynesburg, Ohio.

	Ft.	in
Shale.		
Coal	1	1
Clay and pyrite	1	1½
Coal	1	8½
Clay.		
	3	11

A sample taken at this place showed 8.2 per cent ash, 2.66 per cent sulphur, and a heating value of 12,560 B. t. u. The coal is mined for railroad shipment in Osnaburg Township and was formerly worked on this scale in the Nimishillen Valley, south of Canton, where the bed ranges from 2 to 3 feet in thickness and is divided into two benches by a clay or shale parting about 2 inches thick, as shown in figure 17, B, which is a section of this bed measured in Nimishillen Township. The area of Middle Kittanning coal in Stark County is large, and in the not distant future the coal will be extensively mined.

Carroll County.—In Carroll County, which lies south of Columbiana and Stark counties, the Middle Kittanning coal is above drainage in Rose and Brown townships, where it has long been mined in a small way but does not appear to be of great value.

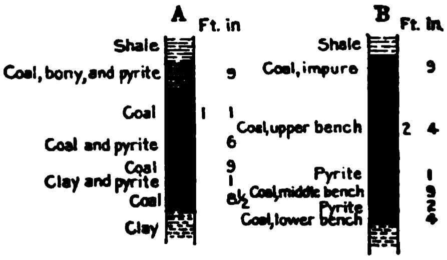


FIGURE 18.—Sections of Middle Kittanning (No. 6) coal bed in Tuscarawas County, Ohio. A, Somerdale, Fairfield Township; B, Gnadenhutten, Clay Township.

Tuscarawas County.—Tuscarawas County, one of the large coal-producing counties of Ohio, derives probably 90 per cent of its fuel from the Middle Kittanning bed. The mines, which are not evenly distributed, are grouped in four districts—Valley Junction, east of New Philadelphia, south of New Philadelphia, and Uhrichsville. However, the Middle Kittanning coal bed is not restricted to these districts, but is found in every township in the county and has been mined in all except Perry. In the northwestern part of the county, however, it lies so near the hilltops that its area is small. Moreover, it is thin in that region, generally not exceeding 3 feet; whereas in those parts where it is most extensively mined it is 3 feet 6 inches to 5 feet thick, and, according to Orton, is of superior quality. The coal, which in Stark County consists of two benches, consists of three in most places in Tuscarawas County. The character of the Middle Kittanning coal bed in this county is represented by figures 18 and 19.

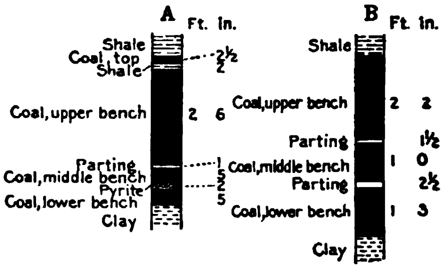


FIGURE 19.—Sections of Middle Kittanning (No. 6) coal bed in Tuscarawas County, Ohio. A, Auburn Township; B, Goshen Township.

Section of Middle Kittanning coal from Medville & Goshen Coal Co.'s mine, Warwick Township, Tuscarawas County, Ohio.

Shale.	Ft.	in.
Coal, bony		9
Coal, upper bench	1	9
Parting		½
Coal, middle bench		7
Parting		2½
Coal. lower bench	1	8
Clay.		
	5	0

A sample obtained in this mine, upon analysis, shows moisture 4.1, volatile matter 41.6, fixed carbon 49.1, and ash 5.2 per cent. Its ultimate analysis shows carbon 72.45, hydrogen 5.57, oxygen 12.10, nitrogen 1.42, sulphur 3.25, and ash 5.21 per cent. The heat value is 13,200 B. t. u. An average of 16 samples from various parts of the county shows thickness 3 feet 7 inches, ash 7.3, moisture 4.3, sulphur 3.85 per cent, and heat value 12,800 B. t. u.

The Middle Kittanning coal in Tuscarawas County has moderate strength and is suitable for domestic use, but its great market is for steam production. The quantity of the coal is large, and the county will be an important source of fuel for many years.

Coshocton County.—Coshocton County, which lies southwest of Tuscarawas, contains a large area of the Middle Kittanning coal in the southeastern part. The coal is extensively worked for railroad shipment near Muskingum River below Coshocton and southeast of that town in Lafayette Township. The coal in the southern part of the county consists generally of two benches with a parting near the bottom ranging from 1 inch to 2 inches in thickness, as shown in figure 20, A and B, and figure 21, A. In the northern part of the county it is in places free from partings, as shown in figure 21, B

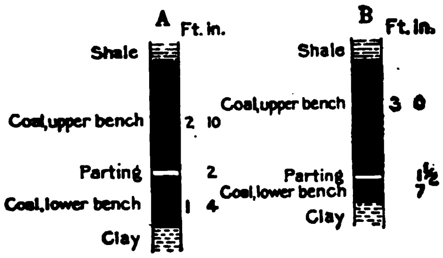


FIGURE 20.—Sections of Middle Kittanning (No. 6) coal bed in Coshocton County, Ohio. A, Franklin Township; B, Virginia Township.

An average of 11 samples from various parts of the county shows thickness 3 feet 2 inches, ash 6.8, moisture 5.5, sulphur 3.82, and heat value 12,560 B. t. u. These figures show that the coal is similar to that of the same bed in Tuscarawas County. Incidentally, the coal is used for the same purposes.

Guernsey County.—The coal is mined for railroad shipment in the northwest corner of Guernsey County and also a short distance north of the county seat, Cambridge.

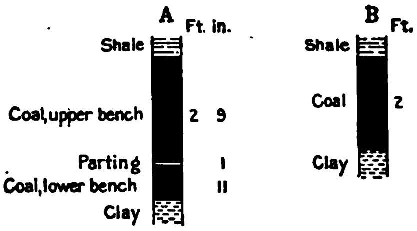


FIGURE 21.—Sections of Middle Kittanning (No. 6) coal bed in Coshocton County, Ohio. A, Jackson Township; B, Clark Township.

Muskingum County.—The Middle Kittanning coal underlies nearly the whole of Muskingum County east of Muskingum River and parts of Harrison, Brush Creek, Newton, and Perry townships west of the river. Its area is therefore large. However, it passes below drainage in Rich Hill, Union, and southern Highland townships, and very little is known of it in that territory. It is mined for local use in every township where it should appear above drainage and for railroad shipment on the west side of Muskingum River.

Orton says:

> The seam falls short of 3 feet in parts of the field, and it nowhere yields fully 4 feet of coal, but it holds, with surprising steadiness, a measure ranging from 30 to 42 inches of coal. Its structure, too, is maintained with great regularity over large areas.

The coal bed, as shown by the following section, consists of two benches separated by a thin layer of shale or clay:

Section of Middle Kittanning coal bed in Birkhimer mine, Madison Township, northern Muskingum County, Ohio.

[See fig. 22, A.]

Shale.	Ft.	in.
Coal, upper bench	2	1
Parting		1½
Coal, lower bench		7
Clay.		
	2	9½

Section of Middle Kittanning coal bed in Walnut Hill Coal Co.'s mine, sec. 13, Brush Creek Township, Muskingum County, Ohio.

	Ft.	in.
Shale	20	0
Coal, upper bench	1	7
Parting		½
Coal, lower bench	2	0
Clay.		
	23	7½

A sample obtained in this mine gave, in proximate analysis, moisture 5.1, volatile matter 39.7, fixed carbon 45.4, and ash 9.8 per cent; and in ultimate analysis carbon 65.74, hydrogen 5.32, oxygen 12.49, nitrogen 1.14, sulphur 5.54, and ash 9.77 per cent. The heat value is 12,240 B. t. u. Figure 22, B, shows the character of the bed in Harrison Township.

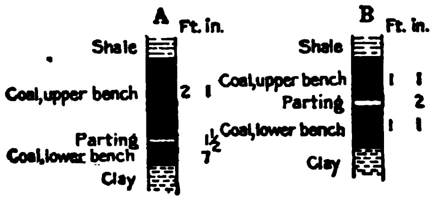


FIGURE 22.—Sections of Middle Kittanning (No. 6) coal bed in Muskingum County, Ohio. A, Madison Township; B, Harrison Township.

Perry County.—The Middle Kittanning coal is found wherever due in the eastern half of Perry County, and in normal structure and thickness except in the southern tier of townships, where it thickens and forms part of the Hocking Valley coal field. The structure and thickness of the bed in the northern part of the county are shown in figure 23, A, and in the central part in figure 23, B. North of these southern townships its area is large and its thickness, structure, and quality are similar to those prevailing in Muskingum County. Throughout this area the coal is extensively mined for railroad shipment as well as for local use.

The thickness and quality of the coal between Muskingum River and the Hocking Valley field are well shown in the following average of 10 measurements and samples: Thickness 3 feet 4 inches, ash 8.4, moisture 5.9, sulphur 3.72 per cent, and heat value 12,310 B. t. u.

Hocking Valley field.—The Hocking Valley coal field, as outlined by Orton, consisted of those parts of Perry, Hocking, and Athens counties where the Middle Kittanning bed is 5 feet or more in thickness. This includes parts of Coal, Salt Lick, and Monroe townships, Perry County; parts of Ward, Green, and Starr townships, Hocking County; and parts of Trimble, Dover, York, Waterloo, Athens, and Canaan townships, Athens County. Orton computed the area of the field at about 94,000 acres. Recent drilling by F. A. Ray has brought to light much additional information regarding this coal bed and has materially changed Orton's southern limit, which is now placed approximately 2 miles south of Athens and 1 mile south of New Marshfield and Mineral, and his western limit, which is now placed near the outcrop of the coal. It must not be understood, however, that within these boundaries the coal everywhere equals or approaches 5 feet in thickness, for in many places it is less and in large areas it is cut out entirely. The greatest change is along the eastern border, which is marked by the "faulted" or barren area that in the main lies just east of the valley of Sunday Creek. The map (Pl. III) by F. A. Ray shows for the first time the Jumbo "fault," which is not a fault at all in the technical sense but an area where the coal is cut out by sandstone or other rock. The cutting appears to have been the work of streams whose current swept away the accumulated vegetal material and deposited in its place sand or mud. Lack of definite knowledge as to the location and extent of this "fault" has caused heavy financial losses to mining companies.

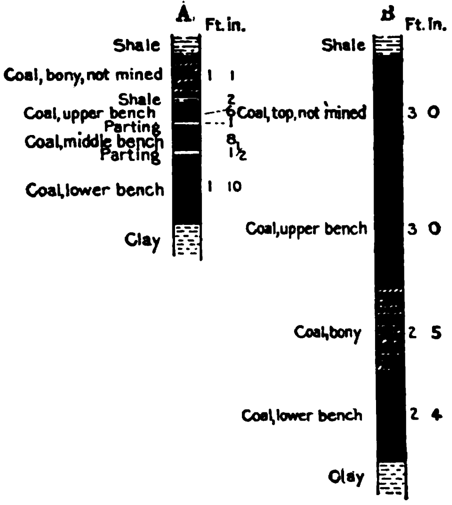


FIGURE 23.—Sections of Middle Kittanning (No. 6) coal bed in Perry County, Ohio. A. Harrison Township; B, Pike Township.

The coal comes in again just east of the fault in Homer, Union, and Marion townships, but it is thin in this area, which is not generally regarded as a part of the Hocking Valley field.

Section of Middle Kittanning coal bed in Walnut Hill Coal Co.'s mine, sec. 13, Brush Creek Township, Muskingum County, Ohio.

	Ft.	in.
Shale	20	0
Coal, upper bench	1	7
Parting		½
Coal, lower bench	2	0
Clay.		
	23	7½

A sample obtained in this mine gave, in proximate analysis, moisture 5.1, volatile matter 39.7, fixed carbon 45.4, and ash 9.8 per cent; and in ultimate analysis carbon 65.74, hydrogen 5.32, oxygen 12.49, nitrogen 1.14, sulphur 5.54, and ash 9.77 per cent. The heat value is 12,240 B. t. u. Figure 22, B, shows the character of the bed in Harrison Township.

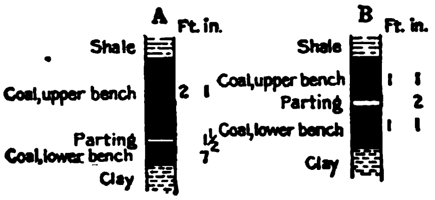


FIGURE 22.—Sections of Middle Kittanning (No. 6) coal bed in Muskingum County, Ohio. A, Madison Township; B, Harrison Township.

Perry County.—The Middle Kittanning coal is found wherever due in the eastern half of Perry County, and in normal structure and thickness except in the southern tier of townships, where it thickens and forms part of the Hocking Valley coal field. The structure and thickness of the bed in the northern part of the county are shown in figure 23, A, and in the central part in figure 23, B. North of these southern townships its area is large and its thickness, structure, and quality are similar to those prevailing in Muskingum County. Throughout this area the coal is extensively mined for railroad shipment as well as for local use.

The thickness and quality of the coal between Muskingum River and the Hocking Valley field are well shown in the following average of 10 measurements and samples: Thickness 3 feet 4 inches, ash 8.4, moisture 5.9, sulphur 3.72 per cent, and heat value 12,310 B. t. u.

Hocking Valley field.—The Hocking Valley coal field, as outlined by Orton, consisted of those parts of Perry, Hocking, and Athens counties where the Middle Kittanning bed is 5 feet or more in thickness. This includes parts of Coal, Salt Lick, and Monroe townships, Perry County; parts of Ward, Green, and Starr townships, Hocking County; and parts of Trimble, Dover, York, Waterloo, Athens, and Canaan townships, Athens County. Orton computed the area of the field at about 94,000 acres. Recent drilling by F. A. Ray has brought to light much additional information regarding this coal bed and has materially changed Orton's southern limit, which is now placed approximately 2 miles south of Athens and 1 mile south of New Marshfield and Mineral, and his western limit, which is now placed near the outcrop of the coal. It must not be understood, however, that within these boundaries the coal everywhere equals or approaches 5 feet in thickness, for in many places it is less and in large areas it is cut out entirely. The greatest change is along the eastern border, which is marked by the "faulted" or barren area that in the main lies just east of the valley of Sunday Creek. The map (Pl. III) by F. A. Ray shows for the first time the Jumbo "fault," which is not a fault at all in the technical sense but an area where the coal is cut out by sandstone or other rock. The cutting appears to have been the work of streams whose current swept away the accumulated vegetal material and deposited in its place sand or mud. Lack of definite knowledge as to the location and extent of this "fault" has caused heavy financial losses to mining companies.

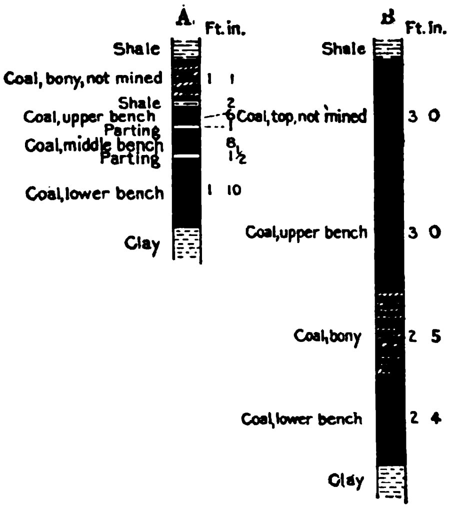
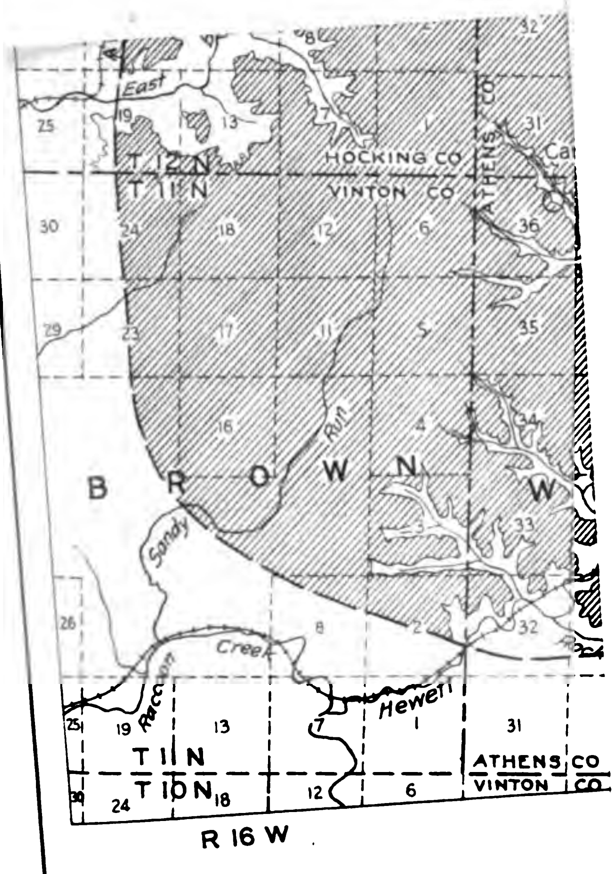


FIGURE 23.—Sections of Middle Kittanning (No. 6) coal bed in Perry County, Ohio. A, Harrison Township; B, Pike Township.

The coal comes in again just east of the fault in Homer, Union, and Marion townships, but it is thin in this area, which is not generally regarded as a part of the Hocking Valley field.



MAP OF THE HOCKING VAI

Broken line

Section of Middle Kittanning coal bed in Walnut Hill Coal Co.'s mine, sec. 13, Brush Creek Township, Muskingum County, Ohio.

	Ft.	In.
Shale	20	0
Coal, upper bench	1	7
Parting		½
Coal, lower bench	2	0
Clay.		
	23	7½

A sample obtained in this mine gave, in proximate analysis, moisture 5.1, volatile matter 39.7, fixed carbon 45.4, and ash 9.8 per cent; and in ultimate analysis carbon 65.74, hydrogen 5.32, oxygen 12.49, nitrogen 1.14, sulphur 5.54, and ash 9.77 per cent. The heat value is 12,240 B. t. u. Figure 22, B, shows the character of the bed in Harrison Township.

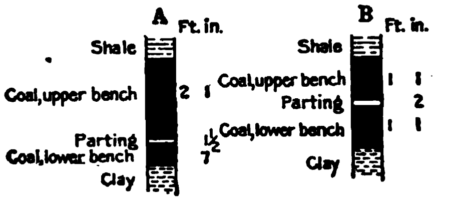


FIGURE 22.—Sections of Middle Kittanning (No. 6) coal bed in Muskingum County, Ohio. A, Madison Township; B, Harrison Township.

Perry County.—The Middle Kittanning coal is found wherever due in the eastern half of Perry County, and in normal structure and thickness except in the southern tier of townships, where it thickens and forms part of the Hocking Valley coal field. The structure and thickness of the bed in the northern part of the county are shown in figure 23, A, and in the central part in figure 23, B. North of these southern townships its area is large and its thickness, structure, and quality are similar to those prevailing in Muskingum County. Throughout this area the coal is extensively mined for railroad shipment as well as for local use.

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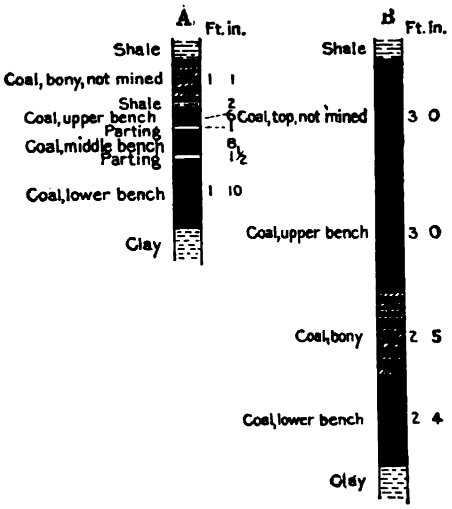
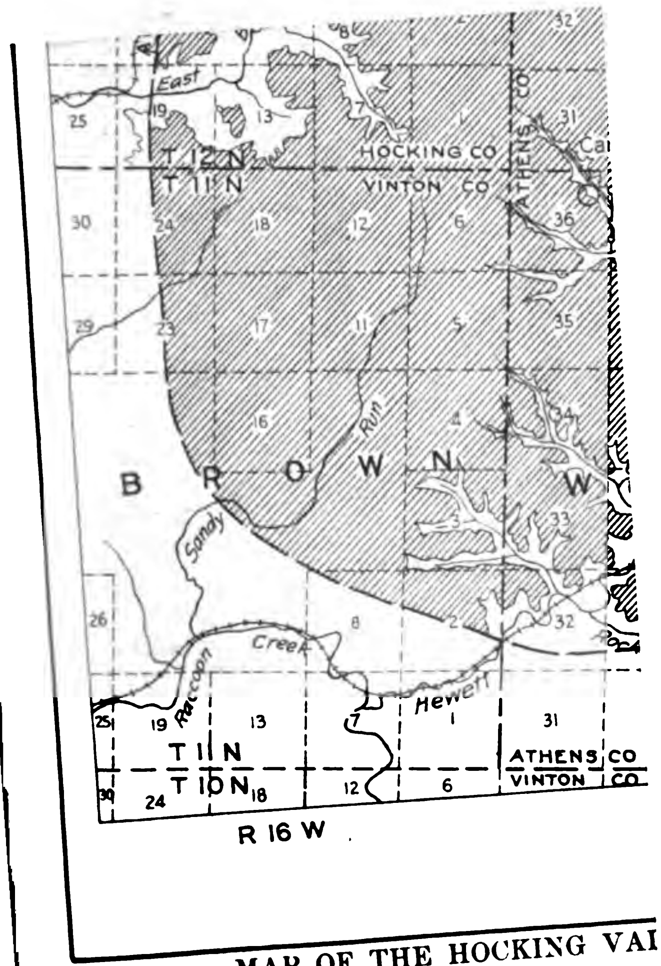


FIGURE 23.—Sections of Middle Kittanning (No. 6) coal bed in Perry County, Ohio. A, Harrison Township; B, Pike Township.

The coal comes in again just east of the fault in Homer, Union, and Marion townships, but it is thin in this area, which is not generally regarded as a part of the Hocking Valley field.



MAP OF THE HOCKING VAI

Broken line

The proximate analysis of a sample from this mine shows moisture 7.3, volatile matter 32.4, fixed carbon 53.6, and ash 6.7 per cent; the ultimate analysis shows carbon 69.46, hydrogen 5.45, oxygen 16.16, nitrogen 1.34, sulphur 0.86, and ash 6.73 per cent. The heat value is 12,410 B. t. u.

Section of Middle Kittanning coal bed in mine of Continental Coal Co., sec. 4 or 5, Ward Township, Hocking County, Ohio.

	Ft.	In.
Shale:		
Coal, supplementary bench, rejected	2	0
Parting		3
Coal, top bench	3	0
Parting		5
Coal, middle bench	1	5
Parting		1
Coal, lower bench	2	1
Clay.		
	9	3

A proximate analysis of a sample from this mine shows moisture 7.6, volatile matter 34.0, fixed carbon 52.6, and ash 5.8 per cent; and an ultimate analysis shows carbon 70.05, hydrogen 5.52, oxygen 16.39, nitrogen 1.42, sulphur 0.77, and ash 5.85 per cent. The heat value is 12,510 B. t. u. The character of the coal bed in Hocking County is shown in figure 26, A.

The composition of the coal is shown by the following average of 8 analyses of samples from various parts of the Hocking Valley field to be ash 6.2, moisture 7.3, and sulphur 1.22 per cent. The heating value is 12,500 B. t. u.

These figures show but little difference in composition from that of the coal in Coshocton, Tuscarawas, Muskingum, and northern Perry counties, and in fact regularity in composition is one of the characteristics of the bed. The coal of the Hocking Valley field is open burning, low in sulphur, and moderate in ash. It was formerly used in the raw state in making pig iron, but that practice was long ago discontinued. The fuel has had a large sale for domestic purposes, but the great demand has always been for steam production. The coal is fairly hard and tough and so stands transportation relatively well. This quality has won for it a good market in the Northwest.

In early days coal was shipped north from this field by canal, but the quantity was relatively small. In 1869 the Hocking Valley Railway was completed to Columbus and in 1880 the Toledo & Ohio Central Railway. These lines gave a good outlet to Columbus, where connections were made with other roads. When, a few years later, these lines were extended to Toledo the market was greatly expanded and the Hocking Valley field became one of the largest producers in this country. The figures below show the production of Perry, Hocking, and Athens counties, and that of the Hocking Valley field would not be notably smaller.

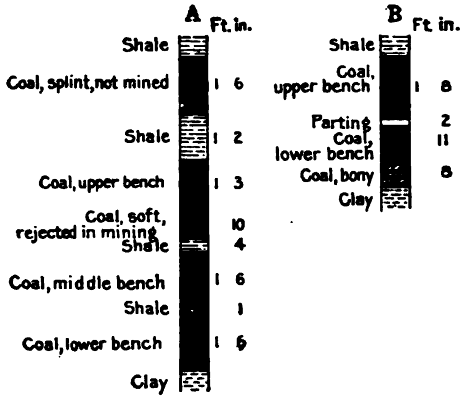


FIGURE 26.—Sections of Middle Kittanning (No. 6) coal bed in Ohio. A, Ward Township, Hocking County; B, Swan Township, Vinton County.

Coal production for certain years of Perry, Hocking, and Athens counties, in short tons.

1883	3,439,873
1890	4,446,299
1900	7,166,916
1913	8,824,820
1914	5,716,203
1915	4,921,493

The zenith of the field's prosperity has been passed, though it will be a large producer for perhaps another half century. Within the last 15 years extensive efforts with the drill have been made to find new areas of coal under cover to the east and south, but the results have not been wholly successful. The best area discovered by this work is at Canaanville, 6 miles east of Athens, where the coal, found at a depth of 412 feet, is about 5 feet thick and has the normal structure and composition of the bed in the Hocking Valley field. It appears to be a lens-shaped block of coal and not a continuous bed, and other areas that have been discovered thus far also seem to lack continuity.

The Middle Kittanning coal extends southwest from the Hocking Valley field and is mined for railroad shipment in the triangle formed by Hocking River on the north, the

Baltimore & Ohio Railroad on the south, and the western boundary of Athens County. In places in the northern part of this area the coal bed has the same thickness and structure that it has in the Hocking Valley field, but elsewhere it is thinner and has only two or three benches. In other words, the "supplementary" bench is not present.

Vinton County.—The Middle Kittanning coal underlies a large part of the eastern half of Vinton County and has been mined for railroad shipment at widely different points, Moonville near the Athens County line, Zaleski, and north of McArthur. The thickness and structure of the bed in this county are well shown in the following sections:

Section of Middle Kittanning coal bed at Moonville, Ohio.

	Ft.	in.
Coal, bony.		
Clay		4
Coal	2	4
Shale or clay		2
Coal		5
	3	3

Section of Middle Kittanning coal bed in Cherry mine, sec. 3, Swan Township, Vinton County, Ohio.

[See fig. 26, B.]

	Ft.	in.
Shale.		
Coal, upper bench	1	8
Parting		2
Coal, lower bench		11
Coal, bony		8
	3	5

A proximate analysis of a sample of coal from this mine shows moisture 4.9, volatile matter 39.2, fixed carbon 45.8, and ash 10.1 per cent; an ultimate analysis shows carbon 66.26, hydrogen 5.40, oxygen 12.71, nitrogen 1.23, sulphur 4.25, and ash 10.15 per cent. The heat value is 12,320 B. t. u. Although the heat value of this coal is fairly good, its percentages of ash and sulphur are high.

Section of Middle Kittanning coal bed on the Baltimore & Ohio Railroad at Zaleski, Ohio.

	Ft.	in.
Shale.		
Coal, top bench	1	5
Parting		4
Coal, middle bench	1	8
Parting		1
Coal, lower bench		2
	3	8

The coal is thin in the southern part of Vinton County and is not mined for shipment, but near Hamden it is worked for burning brick.

Jackson, Gallia, and Lawrence counties.—The Middle Kittanning coal is found well up in the hills in the eastern tier of townships in Jackson County, where it usually ranges from 18 to 24 inches in thickness. It crosses Greenfield Township of Gallia County, where it has the character shown in figure 27, A. It can be readily traced across Lawrence County, though it is too thin to be of much value. It outcrops along Symmes Creek and its western tributaries, but it exceeds 2 feet 6 inches in thickness in few places. It has long been mined for local use at Sheridan on Ohio River, where it measures 2 feet 10 inches to 4 feet and is without partings. A section of the coal bed in this locality is shown in figure 27, B. Above this bed, forming the roof, are a few inches of shale and coal. An analysis of a sample from this place shows 10.9 per cent ash, 3.32 per cent sulphur, and a heating value of 11,930 B. t. u.

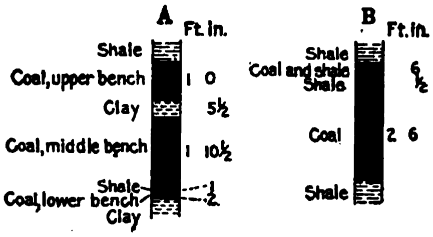


FIGURE 27.—Sections of Middle Kittanning (No. 6) coal bed in Gallia and Lawrence counties, Ohio. A, Greenfield Township; B, Perry Township.

LOWER FREEPORT (NO. 6a) COAL BED.

The Lower Freeport (No. 6a) coal is of little value in Ohio and is worked in a fairly large way only at Steubenville. The coal as a rule lies 30 to 60 feet above the Middle Kittanning bed, whose prominence makes identification easy.

The Lower Freeport bed was once mined near Lisbon and was known locally as the Whan coal. Its thickness was as much as 5 feet, but its area was small. Southeast, toward East Liverpool, the coal is thinner, being 2 feet or less, and in places is represented by shale only. It has been mined in a small way along Yellow Creek, where it is known as the Roger coal, and has in places a thickness in excess of 3 feet. South of the mouth of Yellow Creek the Lower Freeport coal has been opened at many places in the hills facing the Ohio Valley, where its thickness is 30 inches or more.

The Lower Freeport coal is mined in the vicinity of Steubenville under the name Steubenville Shaft coal. The first shaft was sunk in 1855, and the coal was reached at a depth of about 187 feet. Since that time mining has been in progress, but coal is no longer shipped.

Section of Lower Freeport coal bed under Steubenville, Ohio.

[See fig. 28, A.]

	Ft.	in.
Shale.		
Coal	3	0
Parting		½
Coal		10
Clay.		
	3	10½

Although the bed in places attains a thickness of 5 feet, its usual measurement is about 4 feet. The coal is clean, has a bright luster, mines in small pieces, and cokes. It was formerly used rather extensively for coking, but it could not compete with the famous product from Connellsville, Pa., and most of the ovens fell into decay; only a few are now in use. The coal has had a large use in rolling mills, and the La Belle Iron Works operates a mine for its own supply. It is a good steam fuel and has long had a market in Steubenville for domestic purposes.

The limits of the Steubenville field are not known, but the coal has been reached by shafts as far south as Rush Run, 10 miles below the courthouse. At Brilliant 5 feet of coal were found and at Rush Run 7 feet, but the upper and lower foot is of poor quality and for that reason was left in the mine. The coal bed is irregular in thickness, being in places absent and in other places too thin to work. No mining has been done from this shaft for many years. West of Steubenville the coal is under thick cover and no data at hand as to its thickness or quality. It probably extends north and northwest to Yellow Creek and in that event underlies a large area. The field is worthy of exploration and may prove valuable when better and more available supplies have been exhausted.

The Lower Freeport coal is the basis of an important mining industry in the vicinity of Amsterdam, Jefferson County, and north to Bergholz, being worked by four or five railroad shipping mines. In those at Amsterdam shafts are necessary, but about 3½ miles farther northeast the coal rises to the surface along the valley of Yellow Creek. It is undoubtedly the same as the Roger coal of the Ohio Valley.

Core-drill and well-record data show a large area of workable coal in the vicinity of Amsterdam and also eastward and southwestward for miles. There are, however, barren areas, and careful testing will be necessary to prove the extent of the coal.

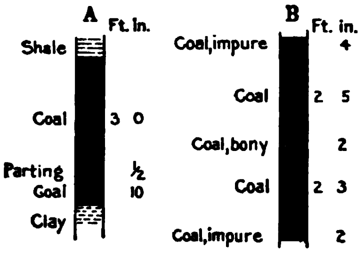


FIGURE 28.—Sections of Lower Freeport (No. 6a) coal bed in Jefferson County, Ohio. A, Steubenville; B, Amsterdam.

The character of the bed in this vicinity is illustrated in figure 28, B, and also by the following sections:

Section of Lower Freeport coal bed in Amsterdam mine, a mile south of Amsterdam, Ohio.

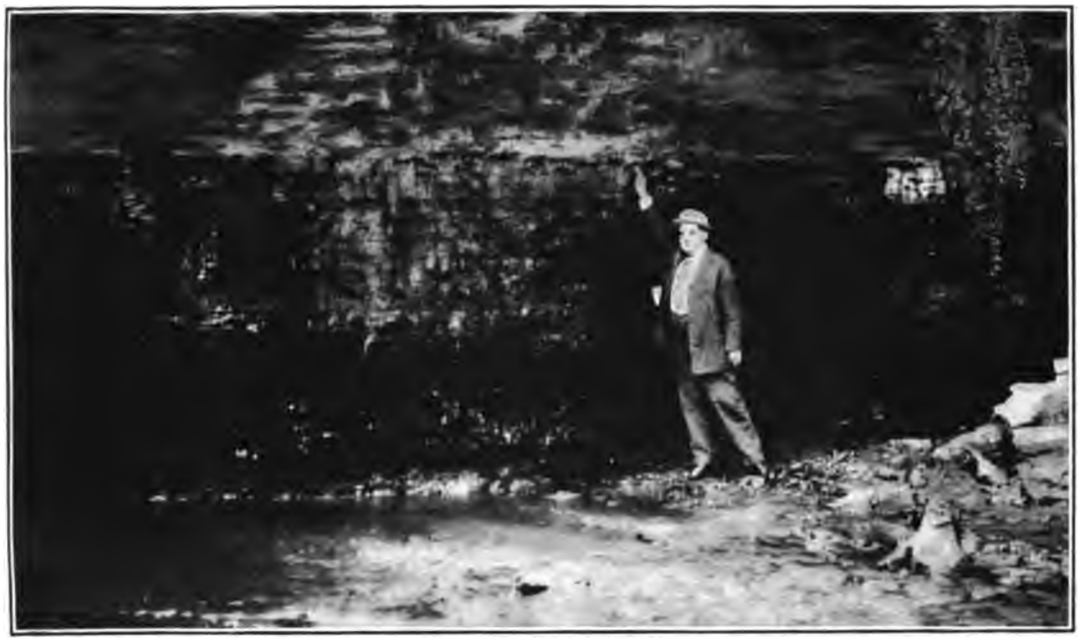
	Ft.	in.
Coal, bony	1	2
Coal	1	6½
Coal, bony		3
Coal	1	11
Coal, impure		5
Shale.		
	5	3½

Section of Lower Freeport coal bed in Elizabeth mine, 2 miles east of Amsterdam, Ohio.

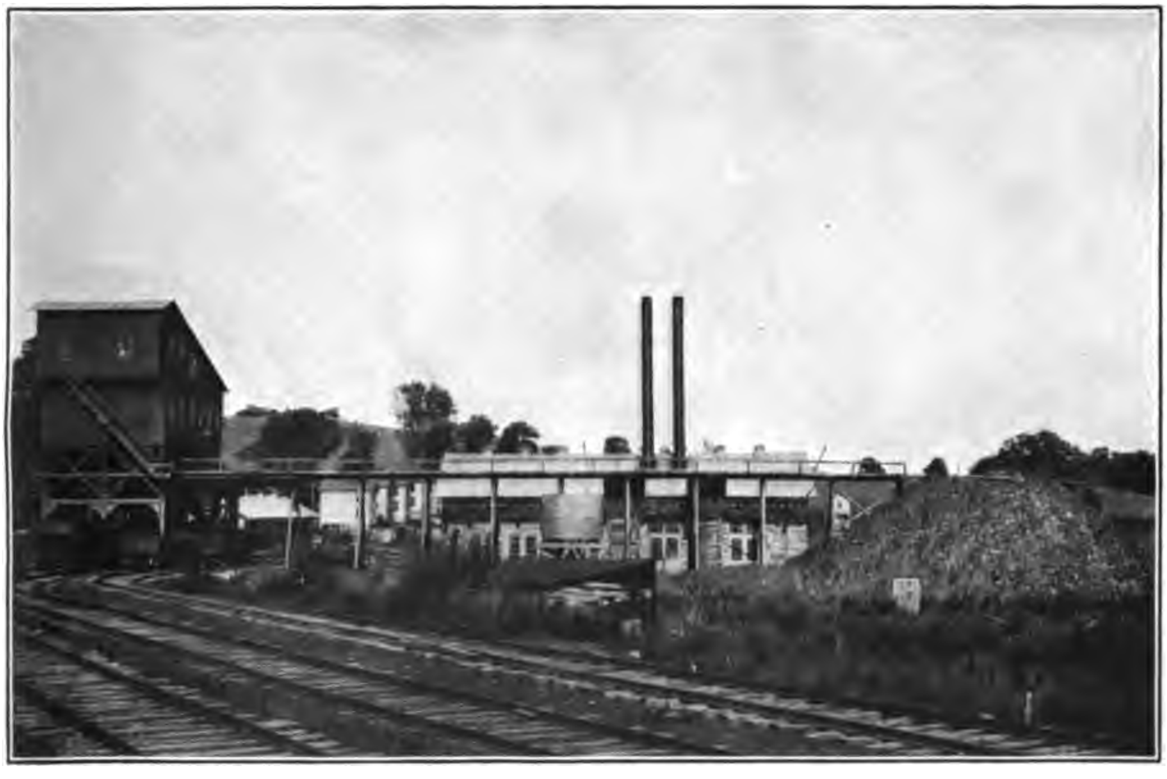
	Ft.	in.
Coal, bony		4½
Coal		6
Coal, bony		1
Coal	1	7
Coal, bony		3½
Coal	1	9½
Shale.		
	4	7½

The average of the two samples from this mine gave, in proximate analysis, moisture, 3.4, volatile matter 38.0, fixed carbon 51.6, and ash 7.0 per cent, and in ultimate analysis carbon 73.31, hydrogen 5.40, oxygen 10.15, nitrogen 1.46, sulphur 2.71, and ash 6.97 per cent. The heat value is 13,390 B. t. u.

The Lower Freeport coal can be followed southwest from Columbiana and Jefferson counties to the Hocking Valley, but it attains a thickness of 3 feet in few places and hence is of no value at present. In sec. 9, Clayton Township, Perry County, the bed is 3 feet 3 inches thick and has been mined locally by farmers. Much the same conditions prevail



A. UPPER FREEPORT COAL BED IN CREEK BANK, SALINEVILLE, COLUMBIANA COUNTY, OHIO.



B. SHAFT MINE ON PITTSBURGH COAL BED AT LAFERTY, BELMONT COUNTY, OHIO.

in Pike Township, but it is thicker in the vicinity of Moxahala, Pleasant Township, where it measures as much as 5 feet. However, the bed is irregular in thickness and the coal is high in sulphur. It has been mined at this place and was once used for making pig iron.

The coal attains workable thickness in Vinton County and has been mined in the vicinity of Hamden Furnace, where it measures 3 feet 8 inches. At present, however, it is not mined in either Vinton or Jackson counties except by stripping along streams. The thickness of the bed in these two counties rarely exceeds 20 inches. The coal is found in Lawrence County, where it is known as the Hatcher bed, but it rarely attains 2 feet 6 inches in thickness. At present it is mined in a very small way along Little Ice Creek in the southern part of the county.

UPPER FREEPORT (NO. 7) COAL BED.

General features.—The Upper Freeport (No. 7) is the third most important coal bed in Ohio, the more valuable ones being the Middle Kittanning (No. 6) and the Pittsburgh (No. 8). The relation of this bed to underlying ones is shown in the sections on page 42. The Upper Freeport coal, like the Middle Kittanning, extends across the State from Columbiana County to Lawrence, but it lacks the persistence and regularity of the Middle Kittanning. In places it is well developed and worked on a large scale, but throughout more extensive areas it is thin and of little value. In places the Mahoning sandstone forms the roof, and in some of these it dips down and cuts out the coal in whole or in part. The coal is usually tender and hence does not bear transportation well. Moreover, it weathers rapidly. Nevertheless it is well adapted for steam purposes and has a large market.

Columbiana County.—In Columbiana County the Upper Freeport coal has long been mined at East Palestine, near the Pennsylvania line, where Orton measured the following section:

Section of Upper Freeport coal bed at East Palestine, Ohio.

[See fig. 29, A.]

	Ft.	in.
Sandstone, Mahoning.		
Shale, black	24	0
Coal	2	0
Parting		2
Coal	1	6
Clay	2	0
	29	8

The coal bed measures 5 feet in thickness and is mined on a large scale at West Point, about halfway between East Palestine and Salineville. It has the same general structure as that at East Palestine and Salineville, but in places the bench below the parting is high in sulphur and therefore is not worked. At Salineville, another important center of development, the Upper Freeport coal, here known as the "Big vein," has been mined for railroad shipment for more than 50 years. (See Pl. IV, *A*.)

Section of coal in bank of Yellow Creek at Salineville, Ohio.

	Ft.	in.
Shale.		
Coal		8
Shale		¾
Coal	3	0
Shale		1
Coal	1	10
Clay.		
	5	7¾

The upper parting in this section appears to be uncommon, for Orton says that the coal in the vicinity of Salineville has only one parting and that near the bottom. Orton's section is shown in figure 29, B. From this locality the outcrop of the Upper Freeport coal runs northeast and perhaps connects with that at West Point. About a mile west of Salineville the coal becomes so shaly that it can not be marketed, and it thins rapidly to the east and south.

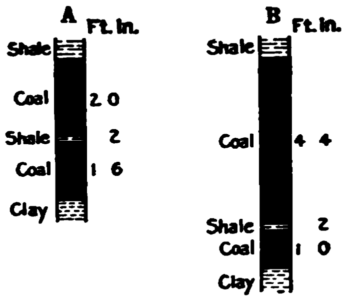


FIGURE 29.—Sections of Upper Freeport (No. 7) coal bed in Columbiana County, Ohio. A, East Palestine; B, Salineville.

Many years ago, when slack coal was simply waste, an unsuccessful effort was made to use the slack at this place for the manufacture of coke. Two grades were produced—a soft coke, which yielded 12.1 per cent of ash and 2.73 per cent of sulphur, for domestic purposes, and a harder variety, which gave 17.5 per cent of ash and 3.66 per cent of sulphur.

Carroll County.—Toward the southwest lies the Dellroy or Sherrodsville field in the southwest corner of Carroll County. This field extends into Monroe Township on the north, nearly to Bowerston on the south, nearly as far as Carrollton on the east, and into Tuscarawas County on the west. A number of mines for railroad shipment have been worked, but all have been abandoned, and the best of the bed is reported to have been worked out. Sherrodsville is said to have had, when mining was at its height, a population of 1,450, but now it has only 350. The coal at its best was 6 feet thick, but it was inconstant, and miners could not count on any definite thickness. The following section by Orton is as representative as a single section can be of an irregular coal bed.

Section of Upper Freeport coal bed at Sherrodsville, Ohio.

	Ft.	in.
Shale, black.		
Coal	2	10
Parting		2
Coal	1	2
Clay.		
	4	2

The coal is still mined at a number of places for the use of farmers, and the supply is adequate for that purpose for generations.

Tuscarawas County.—The Upper Freeport coal is of some importance in Tuscarawas County. It is now mined for railroad shipment near Midvale and Stillwater, but its area near the latter place is reported to be small.

Guernsey County.—Guernsey County, which lies south of Tuscarawas, forms part of one of the largest coal fields of Ohio. Plate V shows four areas in this county in which the Upper Freeport coal bed is of minable thickness. In the northern part of the county the Upper Freeport coal does not appear to have great value, but it is mined in places by farmers. The principal area of workable coal lies south of Cambridge, as shown on Plate V. In this field the coal bed thickens greatly in a short distance south of Cambridge, and it extends southward to the vicinity of Caldwell, Noble County. Cambridge has always been considered headquarters for this field, and the fuel is known in the market as the Cambridge coal. The western boundary of the field, considering it to be limited to territory in which the coal is 4 feet or more thick, is in the longitude of Cambridge and its eastern boundary in that of Lore City. (See Pl. V.) However, to the east the coal is below drainage, and its limits can be determined only by the drill. The field is drained by Wills and Leatherwood creeks and most of the mines are on those streams. The coal dips below Leatherwood Creek near the eastern boundary of Cambridge Township and below Wills Creek about one-half mile north of Byesville.

The structure of the bed, as shown by figure 30, is similar to that already reported from Columbiana and Carroll counties. It consists of two benches, with a parting near the bottom. The maximum thickness is 7 feet, but the Mahoning sandstone in places cuts out the coal in whole or in part, greatly handicapping the field.

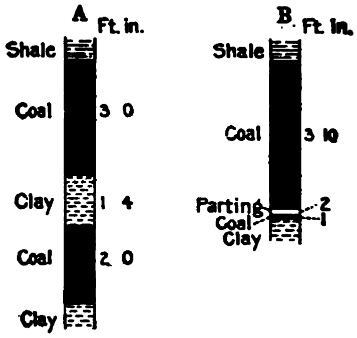


FIGURE 30.—Sections of Upper Freeport (No. 7) coal bed in Guernsey County, Ohio. A, Cambridge Township; B, Center Township.

Section of Upper Freeport or Cambridge coal bed in old Nicholson mine near Cambridge, Ohio.

	Ft.	in.
Shale:		
"Draw slate"		3
Coal with numerous shale partings, none persistent	4	6
Clay		2
Coal	2	4
Clay.		
	7	3

An analysis of this coal from the Forsythe mine, Danford, Guernsey County,[1] gives volatile matter 38.2, fixed carbon 54.0, ash 7.8, and sulphur 3.79 per cent. The heat value is 13,550 B. t. u.

Although the bed has only one regular parting, it has many thin discontinuous ones in places, and these increase the percentage of ash and sulphur. The coal is tender and does not bear transportation well. Its largest use is in steam production, but it has also a fair market for household use. Under normal industrial conditions about 25 mines

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[1] As this analysis is of theoretically dry coal, it should not be compared with other analyses given in this paper.

at Buchtel, Doanville, and near Nelsonville. At its best the bed is 6 feet thick but is somewhat dirty, owing to thin shale or clay partings. An analysis shows 8.3 per cent ash. The coal has been mined in a small way in Waterloo and Athens townships in the same county; its area is large, but the coal in Athens Township is reported to be irregular in thickness.

Vinton County.—The Upper Freeport coal is of very little value in Vinton County, the only known workable areas being in Wilkesville Township, where in a very small area in sec. 22 it has a maximum thickness of 6 feet.

Jackson and Lawrence counties.—The Upper Freeport coal is found in the hills along the eastern border of Jackson County, but it is thin and nowhere mined. The bed has long been worked for local use near Rockcamp in the southern part of Lawrence County, where it has a maximum thickness of 3 feet. It attains importance in Symmes Valley in the eastern part of the county, where it is known as the Waterloo bed. Its thickness there is very irregular and may reach 6 feet, but in places the coal is wanting. The two benches found elsewhere are generally present in this field, but the parting is in many places expanded and may measure a foot or even more. The character of the coal bed in this valley is shown in figure 31, B, and in figure 32, A and B.

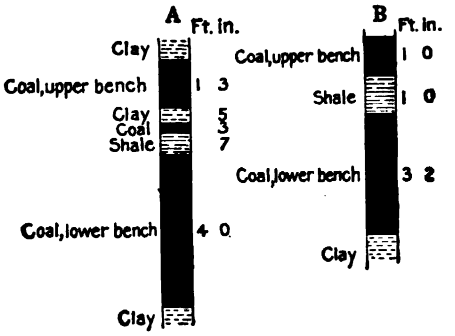


FIGURE 32.—Sections of Upper Freeport (No. 7) coal bed in Lawrence County, Ohio. A, Symmes Township; B, Aid Township.

COAL BEDS IN THE CONEMAUGH FORMATION.

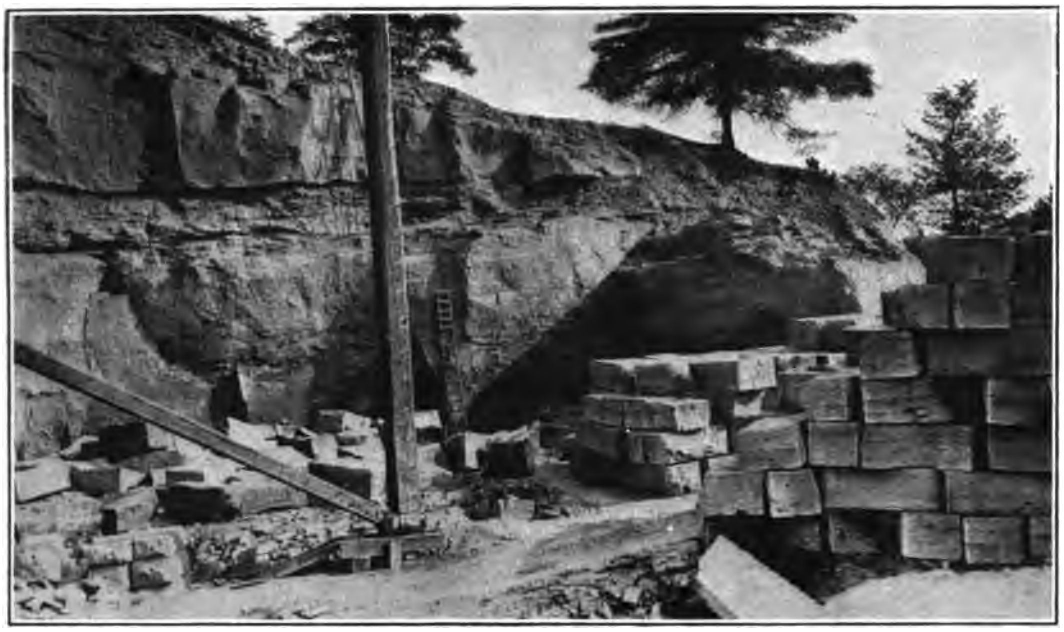
The Conemaugh formation, formerly known as the "Lower Barren Coal Measures," lies between the Upper Freeport (No. 7) and the Pittsburgh (No. 8) coal beds. The formation outcrops in a broad band 5 to 28 miles in width stretching from Columbiana County southwestward to Lawrence County at the extreme southern point of the State. It ranges in thickness from 355 feet in southern Ohio to 500 feet in the eastern part of the State.

Generalized section of the Conemaugh formation in Noble and adjoining counties.

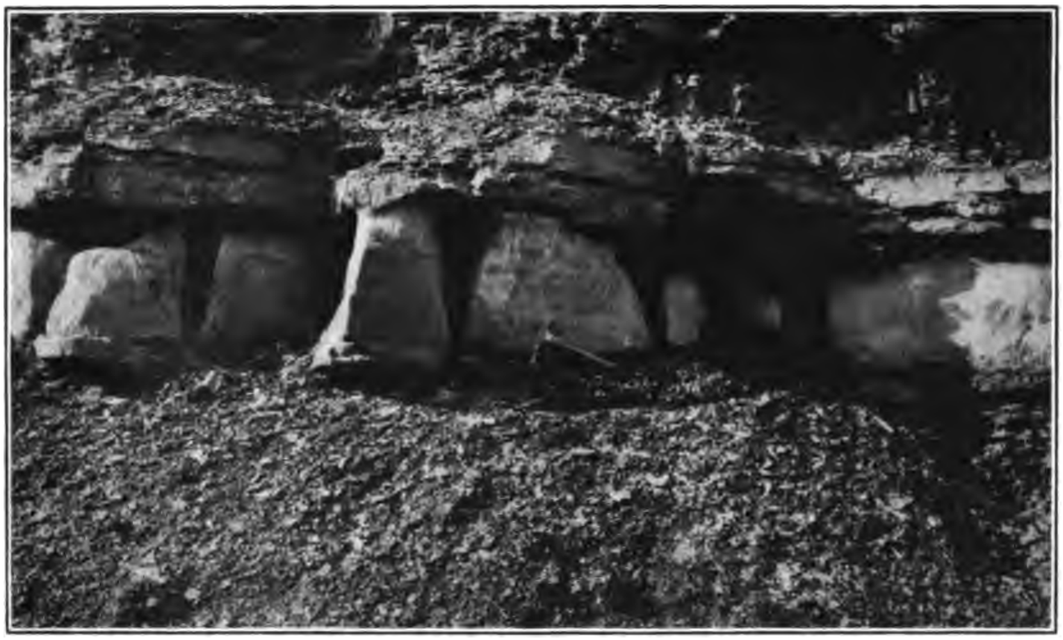
[By D. D. Condit.]

	Feet.
Coal, Pittsburgh, basal member of the Monongahela formation.	
Limestone and clay	5
Sandstone or sandy shale	21
Limestone in several layers, generally with a lumpy brecciated or pebbly surface; buff color common	6
Shale, with alternating beds of sandstone and clay, commonly reddish brown	120
Shale, sandy, or locally sandstone (Morgantown member)	30
Limestone, Ames or "Crinoidal" member	2
Shale	11
Coal, Harlem, usually thin, workable at Harlem Springs, Carroll County.	
Shale or red clay, locally replaced by sandstone (Saltsburg member)	20
Limestone, nodular or in continuous layers	3
Shale, sandy, with local lentils of massive sandstone (First Cow Run sand of oil drillers)	60
Coal, Anderson (Bakerstown of Pennsylvania and West Virginia); 18 inches to 2 feet thick near Lore City and Pleasant City, Guernsey County, and locally of similar thicknesses to the south and southwest in Noble and Morgan counties. The roof shale is black and contains marine fossils.	
Clay, with nodular limestone	11
Limestone, Cambridge member, dark gray, fossiliferous; varying from nodular to a single continuous layer; well suited for use as road material	4
Shale, locally replaced by a bed of massive sandstone (Buffalo member), especially prominent along Stillwater Creek, in Tuscarawas County	38
Shale, dark, with marine fossils and one or more thin coal beds (Brush Creek member)	20
Sandstone, shaly to massive	20
Clay and shale, with one or more limestone layers	10
Sandstone, shaly	45
Shale and clay, with locally a thin coal (Mahoning member)	10
Sandstone, shaly to massive (Mahoning member)	35
Upper Freeport or Cambridge coal, top member of Allegheny formation.	
	471

In southern Ohio, according to Condit, the general section is similar to that just given, though the formation is thinner and presents minor variations.



A. QUARRY IN MAHONING SANDSTONE MEMBER NEAR CORNING, PERRY COUNTY, OHIO.



B. BRUSH CREEK LIMESTONE MEMBER OF THE CONEMAUGH FORMATION NEAR DEXTER, MEIGS COUNTY, OHIO.

General section of the Conemaugh formation in Meigs County, Ohio.

	Ft.	In.
Limestone, nodular or in layers, interlain with clay	4	0
Shale, sandy	45	0
Sandstone (Connellsville member), massive to shaly	30	0
Coal, "blossom."		
Limestone, nodular		8
Shale, sandy, with red beds	38	0
Clay, red, with concretions of hematite	28	0
Shale, sandy	12	0
Limestone (Ames or "Crinoidal" member), impure and sandy in many localities	1	6
Shale, sandy	10	0
Clay shale, red, with nodular limestone ("Round Knob horizon"; "Pittsburgh reds")	34	0
Coal, Anderson (Bakerstown), thin.		
Shale, sandy	33	0
Limestone (Cambridge member), dense, dark gray, fossiliferous; missing in many localities	1	6
Shale, sandy	20	0
Limestone (Brush Creek member), shale, and sandstone, all fossiliferous	30	0
Shale, sandy	5	0
Coal, Mason		6
Sandstone, shaly to massive	22	0
Coal, Mahoning, thin.		
Clay, with ferruginous limestone at top	3	0
Sandstone (Mahoning member), massive	33	0
Coal, Upper Freeport (No. 7); top member of the Allegheny formation.		
	351	2

The rocks of the Conemaugh formation have been described by Condit to consist

> mostly of sandstone, sandy shale, and clay, much of which has a reddish-brown color. Coal beds and limestones are few and thin. All of the beds are characterized by lack of persistence, and vary greatly from place to place as to thickness and appearance. Local erosion planes and unconformities of small magnitude are abundant and occur at all horizons. These hiatuses are shown by conglomerates and truncated strata. Frequently the material of the conglomerates can be traced to some near-by fossiliferous limestone or coal bed. [See Pl. VI, *A*.]

The lower half of the Conemaugh formation is largely of marine origin and includes a number of fossiliferous beds, the highest of which, lying a little above the middle, marks the final invasion of the sea into the Appalachian Basin. All overlying strata lack forms of undoubted marine origin, their fossils being mostly plant remains and certain minute fossils, such as *Spirorbis*, ostracods, and gastropods, generally regarded as fresh-water, with some fish, amphibian, and reptilian bones. Some insect remains are well preserved in the shale. The marine limestones of the lower half of the formation are the most persistent and lithologically uniform (see Pl. VI, *B*), but even these have suffered contemporaneous erosion and are locally missing, owing to unfavorable conditions of deposition, such as the presence of shoals in the sea and continuous sedimentation from rivers.[1]

The coal beds of the Conemaugh formation are thin and unimportant, though they are worked at places by farmers and at one place for railroad shipment. The Mahoning bed is the lowest of these coals and is rated by Condit as the most important. It is known by several local names, such as Groff in the upper Ohio Valley, Strip at Salineville, and Finley along Island Creek in northern Jefferson County. Its most valuable areas are in Columbiana, Jefferson, and Carroll counties, throughout large parts of which the bed ranges from 2 to 3 feet in thickness. Condit states that this coal is at its best in the vicinity of Salineville, where it measures as much as 38 inches, has a shale parting about 10 inches above the base, and lies only 32 feet above the Upper Freeport or "Big vein." About 2 miles west of Salineville, in the eastern part of Carroll County, this coal is worked for railroad shipment by two companies, and it is the only place in Ohio where a coal in the Conemaugh formation is mined for such shipment. Along Island Creek in northern Jefferson County the Mahoning coal bed is from 3 feet to 4 feet 6 inches in thickness and has long been mined for local use. From what has been said it is apparent that the Mahoning coal is at least of marked local value.

The Mason coal, although persistent, is of little value except in eastern Ohio, where it lies about 75 feet above the Upper Freeport coal. Condit states that it is mined at several places along the Youngstown & Ohio River Railroad in Madison Township, Columbiana County, and is from 3 feet to 3 feet 6 inches thick, but these dimensions do not appear to persist throughout wide areas.

The Wilgus coal bed is 18 to 36 inches thick in parts of Gallia and Lawrence counties in the southern part of the State and is worked for a local supply on many farms, especially in the valley of Symmes Creek. The Cambridge limestone forms its roof.

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[1] Condit, D. D., Ohio Geol. Survey, 4th ser., Bull. 17, p. 15, 1912.

The Anderson coal, according to Condit, is workable over much of Muskingum and Morgan counties and in places in Guernsey, Noble, and Harrison counties. In Muskingum County it is reported at its best in Union, Salt Creek, and Blue Rock townships, where its thickness is 2 to 3 feet and its quality is very good. In southwest Harrison County it is 1 foot 6 inches to 3 feet thick, though the 3-foot thickness is not common. It is mined on a few farms. On the property of the Noble Brick Co. at Glenwood station, Noble County, the Anderson coal is 23 inches thick, and it has been opened on many farms along Buffalo Creek in the northern part of this county.

The Barton coal bed, lying about halfway between the Ames and Cambridge limestones, is thin and of small value even locally. In southern Carroll County it is 20 to 24 inches thick and is worked in a few mines. The shale roof is strong and requires little or no timbering. The coal is of good quality.

The Harlem coal, the highest bed of workable thickness in the Conemaugh formation, is at its best in Jefferson, Carroll, and Harrison counties. Harlem Springs, in the southeast part of Carroll County, is its best-known locality and supplies coal to the farmers for miles in all directions. Although the coal does not attain a thickness of 3 feet, it reaches 2 feet 6 inches throughout a broad area.

COAL BEDS IN THE MONONGAHELA FORMATION.

GENERAL FEATURES.

The Monongahela formation, formerly known as the "Upper Productive Coal Measures," outcrops as a broad belt from Jefferson County southwest to Lawrence County and includes parts of Jefferson, Harrison, Belmont, Guernsey, Monroe, Noble, Morgan, Muskingum, Washington, Athens, Meigs, Gallia, and Lawrence counties. The formation has for its basal member the Pittsburgh (No. 8) coal and for its summit the Waynesburg bed. Orton credited the formation with a thickness of 200 feet, and Condit's section differs but little from this. The formation contains three important coal beds, the Pittsburgh, Pomeroy, and Meigs Creek, and two beds of lesser value, the Uniontown and Waynesburg. The relative positions of these are shown in the following section.

Generalized section of the Monongahela formation in Belmont and adjoining counties, Ohio.

[By D. D. Condit.]

	Feet.
Coal, Waynesburg, mined at Somerton, Newcastle, and Hunter, Belmont County; high in ash; usually a solid bed with no persistent clay or bone bands.	
Clay and sandy shale	18
Coal, thin.	
Clay and buff limestone	4
Sandstone, varying from shaly and cross-bedded to massive; quarried west of Miltonsburg, Monroe County	50
Coal, Uniontown; mined near Hunter, Belmont County, and along Sunfish Creek, east of Woodsfield, Monroe County; high in ash and usually has several clay bands.	
Clay, with thin layers of nodular limestone	10
Sandstone, shaly	18
Limestone (Benwood member), numerous beds 1 to 2 feet thick, interlayered with calcareous clay. In the lower portion is a conspicuous bed of olive-green clay	72
Coal, Meigs Creek; workable in Belmont County and also over much of Noble, Washington, and other counties to the southwest; rather high in ash but seldom has persistent bands of clay or bony coal.	
Sandstone, varying from shaly to massive and coarse grained	35
Coal, Lower Meigs Creek; workable in a few localities near Temperanceville, Belmont County, and southward in Monroe County; contains many bands of impurities and much "sulphur."	
Limestone	4
Shale and clay	25
Limestone, yellowish	3
Sandstone, shaly	30
Coal, Pomeroy; thin or wanting	
Limestone, laminated, black, underlain by yellowish limestone layers	4
Shale, sandy	20
Coal, Pittsburgh; present in workable thickness throughout nearly the whole of Belmont County and parts of the surrounding counties.	
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PITTSBURGH (NO. 8) COAL BED.

GENERAL FEATURES.

The Pittsburgh or No. 8 coal is one of the two most important coal beds in Ohio, its only rival being the Middle Kittanning (No. 6) bed, which is more persistent, has a larger acreage, and is of a little better quality. The Pittsburgh coal in Ohio occupies three widely separated fields—the Belmont County field, the Federal Creek field of Morgan and Athens counties, and the Swan Creek field of Gallia County. Outside of these fields the coal is thin and usually worthless.

BELMONT FIELD.

General features.—The Belmont field is by far the largest of the three fields mentioned. It includes nearly the whole of Belmont County, the southern two-fifths of Jefferson County with numerous outliers farther north, the southeastern third of Harrison County, several ridges in the southeastern corner of Guernsey County, the northeastern corner of Noble County, and a somewhat undetermined area in the northern part of Monroe County. (See Pl. VII.)

Ohio River cuts through the coal as far as the southeast corner of Belmont County, where it is said to flow on top of the bed. Several western tributaries, the largest of which are Short Creek, Wheeling Creek, and McMahon Creek, also cut through the coal bed, making it accessible and providing easy routes for railroads. However, throughout a large area in central Belmont County the coal is below drainage and can be reached only by shafting. In Monroe County the coal is everywhere under cover except in the northwest corner, where it has been trenched by the headwaters of Wills Creek.

Throughout this large area the principal structural features of the bed are uniform except along the western border. In the townships fronting on Ohio River the structure is similar to that in the type locality, southwestern Pennsylvania, and is as follows:

Type section of the Pittsburgh coal bed.

Roof coal.
"Draw slate" or overclay.
Breast coal or main bench.
Clay parting.
Bearing-in coal.
Clay parting.
Brick coal.
Clay parting, in some places absent.
Bottom coal.

Along the western border of the field the breast coal thins and in places the bearing-in coal is lacking. In a mine at Temperanceville, Belmont County, the coal bed consists of two benches separated by a shale parting and has a structure similar to that in the Federal Creek and Swan Creek fields. The "draw slate" or overclay commonly ranges in thickness from a few to 18 inches. Above it is the roof coal, which rarely attains a thickness of 2 feet and is not mined. In many places it is associated with shale and forms the mine roof.

Belmont County.—No other county in Ohio is so favored with coal as Belmont. The hilltops in the southern half of the county rise to or above the horizon of the Waynesburg coal, which is a local source of fuel on some of the farms. The next lower coal bed is the Uniontown, which is worked at a score or more places in the county and may become a source of fuel of real value when the much more important beds lying below it have been worked out. The Meigs Creek coal, 3 to 4 feet thick, is 100 to 140 feet below the Uniontown and underlies the entire county except along the west border, in the northeast corner, and in narrow strips along a few streams. More important than all these beds combined, however, is the great Pittsburgh coal bed, 3 to 5 feet thick, which underlies the entire county except the northwest corner, where the headwaters of Stillwater Creek have swept the coal away; the valleys of Wheeling and McMahon creeks; a narrow strip along Ohio River; and a few hundred acres in the southwest corner of the county. Throughout this large area the thickness of the bed and quality of the coal, though subject to some variation, are remarkably uniform. The coal is at its best along the Ohio Valley, where it is thicker, a little lower in ash and moisture, and greater in heat value than elsewhere. Along the river front in the northern part of the county the coal is high in the hills, but its dip carries it to the level of the flood plain in the vicinity of Bellaire and to the bed of the river in the southern part of the county.

As it outcrops so prominently the coal must have been known from the time of settlement and was probably mined for household purposes as early as 1825. Shipment by river was started about 1835 and had become an important industry by 1845, the coal going as far as New Orleans. The Baltimore & Ohio Railroad began hauling coal about 1858 from a mine a mile west of Bellaire and from that time to 1900 the output of the field grew steadily; since 1900 the increase has been very rapid. Belmont County is now by far the largest producer in the State; in 1913, before the disastrous strike, it produced more coal than any other two counties in Ohio. The following figures indicate the growth of the industry:

Production of coal in Belmont County, Ohio, in short tons.

1890	774, 110
1895	846, 643
1900	1, 345, 284
1905	3, 957, 980
1910	8, 265, 019
1913	10, 436, 259
1914	2, 849, 181
1915	4, 304, 566

The shipping mines, of which there are about 50, are distributed along the river front or the Baltimore & Ohio and its branches. As yet the southern two-fifths of this county has hardly been touched and constitutes a fuel body of great value. The coal bed is nearly uniform, but a few sections of it will be given. Figure 33, A and B, shows the coal bed in the northwest corner of the county and figure 34, A and B, in the northeast corner.

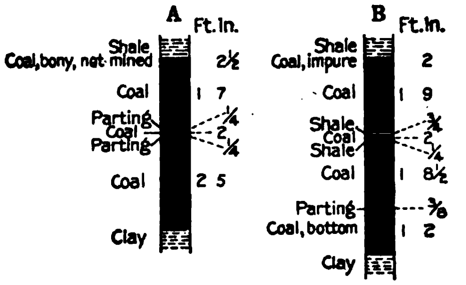

FIGURE 33.—Sections of Pittsburgh (No. 8) coal bed in Belmont County, Ohio. A, Flushing Township; B, Union Township.

Section of Pittsburgh coal bed in Wheeling Valley Coal Co.'s mine at Lafferty, Union Township, Belmont County, Ohio.

[See Pl. IV, *B*, and fig. 33, B.]

	Ft.	in.
"Draw slate"	1	0
Coal, impure, rejected		2
Coal, breast	1	9
Parting		¾
Coal, bearing-in		2
Parting		¼
Coal, brick	1	8½
Parting		⅜
Coal, bottom	1	2
	6	⅞

A proximate analysis of a sample from this mine shows moisture 4.5, volatile matter 36, fixed carbon 48.8, and ash 10.7 per cent; an ultimate analysis shows carbon 68.24, hydrogen 4.85, oxygen 10.60, nitrogen 1.10, sulphur 4.45, and ash 10.76 per cent. The heat value is 12,430 B. t. u. The surface plant at this mine is shown in Plate IV, *B* (p. 56).

The character of the bed in the vicinity of Bellaire is shown by the following section:

Section of Pittsburgh coal bed in Empire Coal Mining Co.'s mine, 1 mile south of Bellaire, Ohio.

	Ft.	in.
"Draw slate"	1	0
Coal, breast	2	1
Pyrite		⅝
Coal, bearing-in		3
Shale and pyrite		½
Coal, brick, containing six very thin shale partings	1	5
Shale and pyrite		1
Coal, bottom		10
Shale.		
	5	9⅛

The proximate analysis of a sample from this mine shows moisture 3.5, volatile matter 38.6, fixed carbon 51, and ash 6.9 per cent; an ultimate analysis shows carbon 72.06, hydrogen 5.45, oxygen 10.70, nitrogen 1.17, sulphur 3.76, and ash 6.86 per cent. The heat value is 13,190 B. t. u.

This section and analyses may be considered typical of the coal in the dozen or more mines in the vicinity of Bellaire. The coal is well shown along McMahon Creek to a point near Glencoe, where it passes below drainage.

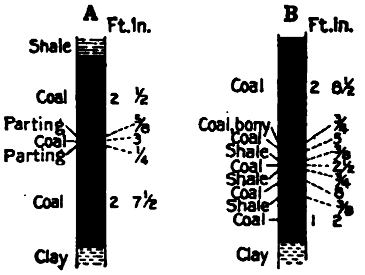

FIGURE 34.—Sections of Pittsburgh (No. 8) coal bed in Belmont County, Ohio. A, Pease Township; B, Colerain Township.

The character of the Pittsburgh coal bed in Mead Township is shown in figure 35, A, and by the following section, which includes the roof coal:

Section of Pittsburgh coal bed in Johnson Bros.' mine near mouth of Pipe Creek, Belmont County, Ohio.

	Ft.	in.
Coal, roof		1½
"Draw slate"	1	4
Coal, breast	2	3
Shale		½
Coal, bearing-in		4½
Shale		½
Coal, brick and bottom	3	2
	7	4

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A proximate analysis of a sample from this mine shows moisture 2.9, volatile matter 37.9, fixed carbon 51.2, and ash 8.0 per cent; an ultimate analysis shows carbon 72.95, hydrogen 5.11, oxygen 8.59, nitrogen 1.04, sulphur 4.31, and ash 8 per cent. The heat value is 13,210 B. t. u.

The "draw slate" is reported to contract in places to an inch and the breast coal to contain in places thin lenses of pyrite. Partings of "smut" not more than one-fourth inch thick were noted in the lower part of the coal bed. The coal at this place is reported to be on a level with the bed of Ohio River. Three diamond-drill tests, made in secs. 2, 8, and 14, Mead Township, disclosed thicknesses of 5 feet 1 inch, 5 feet 5 inches, and 5 feet, respectively, of the Pittsburgh coal bed.

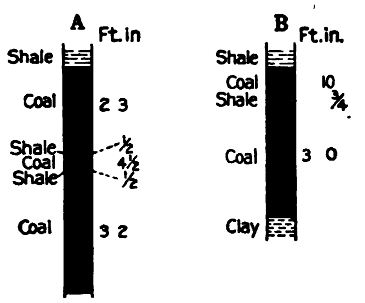

FIGURE 35.—Sections of Pittsburgh (No. 8) coal bed in Belmont County, Ohio. A, Mead Township; B, Somerset Township.

Section of Pittsburgh coal bed in Captina Coal Co.'s mine. Armstrongs Mills, Washington Township, Belmont County, Ohio.

	Ft.	in.
Coal, roof	1	0
Coal, bony, rejected		3
Coal, breast, with three thin partings	2	8
Shale		1
Coal, bearing-in		8½
Coal, brick, with several "smut" layers	1	8½
Shale		½
Coal, bottom, with a few pyrite lenses	1	1
	7	6½

A proximate analysis of a sample from this mine shows moisture 2.8, volatile matter 37.9, fixed carbon 49.9, and ash 9.4 per cent; an ultimate analysis shows carbon 69.76, hydrogen 5.25, oxygen 9.39, nitrogen 1.09, sulphur 5.09, and ash 9.42 per cent. The heat value is 12,990 B. t. u.

This mine is located in the valley of Captina Creek. As its only outlet is a narrow-gage railroad the output is not large. The coal is below drainage everywhere on Captina Creek except near the middle of York Township, where a low anticline brings it above the valley floor.

Section of Pittsburgh coal bed in Jefferies mine Temperanceville, Ohio.

[See fig. 35, B.]

Shale.	Ft.	in.
Coal		10
Shale and pyrite		¾
Coal	3	0
	3	10¾

A proximate analysis of a sample from this mine shows moisture 4.1, volatile matter 37.1, fixed carbon 48.2, and ash 10.6 per cent; an ultimate analysis shows carbon 68.77, hydrogen 4.89, oxygen 9.68, nitrogen 1.10, sulphur 4.95, and ash 10.61 per cent. The heat value is 12,480 B. t. u.

Variations in composition of the Pittsburgh coal from east to west across Belmont County are well shown below:

Variations in Pittsburgh coal in Belmont County, Ohio.

	B. t. u.	Ash.	Sulphur.	Moisture.
Eastern border of field, average of 10 samples	13,000	8.1	3.74	3.6
Middle field, average of 6 samples	12,650	9.0	3.35	4.8
Western border of field, average of 5 samples	12 500	9.9	4.02	4.8

In air-dried samples the moisture is about 3 per cent.

The coal cokes, but the coke, because of its sulphur content, can not compete with that from Connellsville or West Virginia. It was formerly coked in the eastern part of Belmont County, but the practice ceased more than 20 years ago. The great use of the coal is for steam and domestic purposes.

Jefferson County.—Jefferson County, which lies north of Belmont, is the second largest producer of coal in Ohio. In 1912 it had an output of 4,858,529 short tons, nearly all of which came from the Pittsburgh bed. As this coal bed rises northward it has been more extensively eroded in Jefferson than in Belmont County, and it is largely restricted to the higher areas. Short Creek, which crosses the field from west to east, and its northwest tributaries have eroded far below the coal bed, and their valleys are now utilized by railroads. The coal is abundant as far north as the Pennsylvania Railroad, but farther north it is restricted to a few hills and ridges, in only one of which it is of sufficient area to be valuable. The structure and composition of the bed is similar to that in Belmont County.

Section of Pittsburgh coal bed in Wheeling & Lake Erie Coal Mining Co.'s mine No. 2, Dillonvale, Ohio.

[See fig. 36, A.]

	Ft.	in.
Coal, roof.		
Coal		2½
Shale		1½
Coal	1	6
Shale		¾
Coal		1½
"Draw slate"	1	0
Coal, breast	2	6½
Shale		⅝
Coal, bearing-in:		
Coal		1⅝
Parting		⅝
Coal		2¼
Shale		⅜
Coal, brick and bottom	2	8
Clay, reported thickness		7
	9	3¼

The proximate analysis of a sample from this mine shows moisture 3.1, volatile matter 37.9, fixed carbon 49.5, and ash 9.5 per cent; an ultimate analysis shows carbon 69.56, hydrogen 5.22, oxygen 10.77, nitrogen 1.10, sulphur 3.83, and ash 9.52 per cent. The heat value is 12,880 B. t. u.

The mine from which this sample was taken is located in the valley of Short Creek, the most important mining district in the county; and the section given is representative of the coal in that territory. The Ames limestone, of stratigraphic value, lies in the bottom of the valley at Adena, where it is 175 feet below the Pittsburgh coal.

Section of Pittsburgh coal bed in United States Coal Co.'s mine, in extreme northwest corner of Smithfield Township, Jefferson County, Ohio.

[See fig. 36, B.]

	Ft.	in.
"Draw slate"		9
Coal, breast	1	11
Parting		1
Coal, bearing-in		1
Parting		¾
Coal, brick and bottom	2	2
	5	¾

A proximate analysis of a sample from this mine shows moisture 4.3, volatile matter 35.3, fixed carbon 52.5, and ash 7.9 per cent; an ultimate analysis shows carbon 71.34, hydrogen 5.18, oxygen 11.39, nitrogen 1.20, sulphur 3.01, and ash 7.88 per cent. The heat value is 12,860 B. t. u.

This mine is near the northern limit of the Pittsburgh coal bed in Jefferson County and shows fair thickness and good quality. Although no lenses of pyrite are indicated in the section, they are common in the mine.

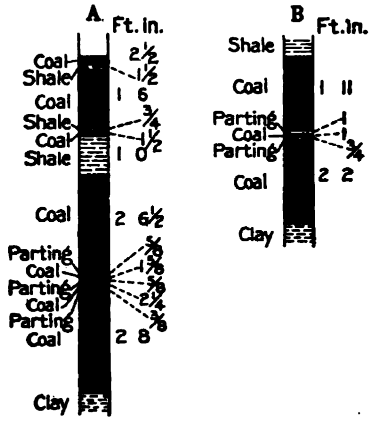

FIGURE 36.—Sections of Pittsburgh (No. 8) coal bed in Jefferson County, Ohio. A, Mount Pleasant Township; B, Smithfield Township.

Section of Pittsburgh coal bed in Dewland Cox & Sons' mine, Brilliant, Ohio.

	Ft.	in.
Coal, breast:		
Coal	1	7
Parting		¼
Coal	1	2
Parting		2½
Coal, bearing-in		2½
Parting		¾
Coal, brick and bottom	2	3½
Clay.		
	5	6½

A proximate analysis of a sample from this mine shows moisture 4.9,[1] volatile matter 33.1, fixed carbon 51.5, and ash 10.5 per cent; an ultimate analysis shows carbon 68.01, hydrogen 5.03, oxygen 11.29, nitrogen 1.12, sulphur 4.09, and ash 10.46 per cent. The heat value is 12,520 B. t. u.

The coal bed, as determined by C. N. Brown with a Y level, is 343 feet above the Wheeling & Lake Erie Railway tracks at Brilliant and

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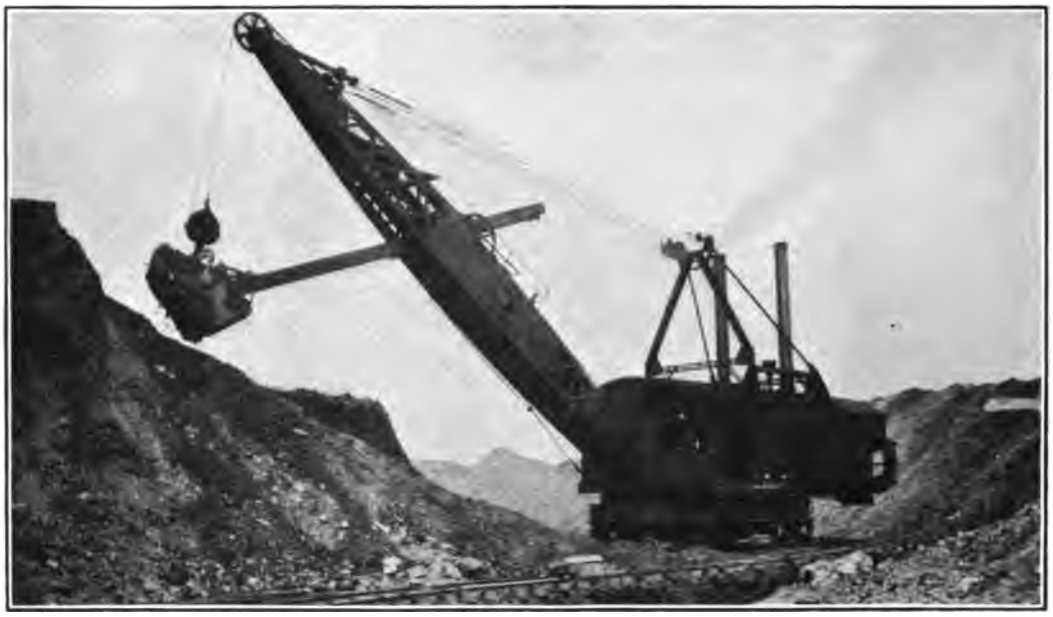
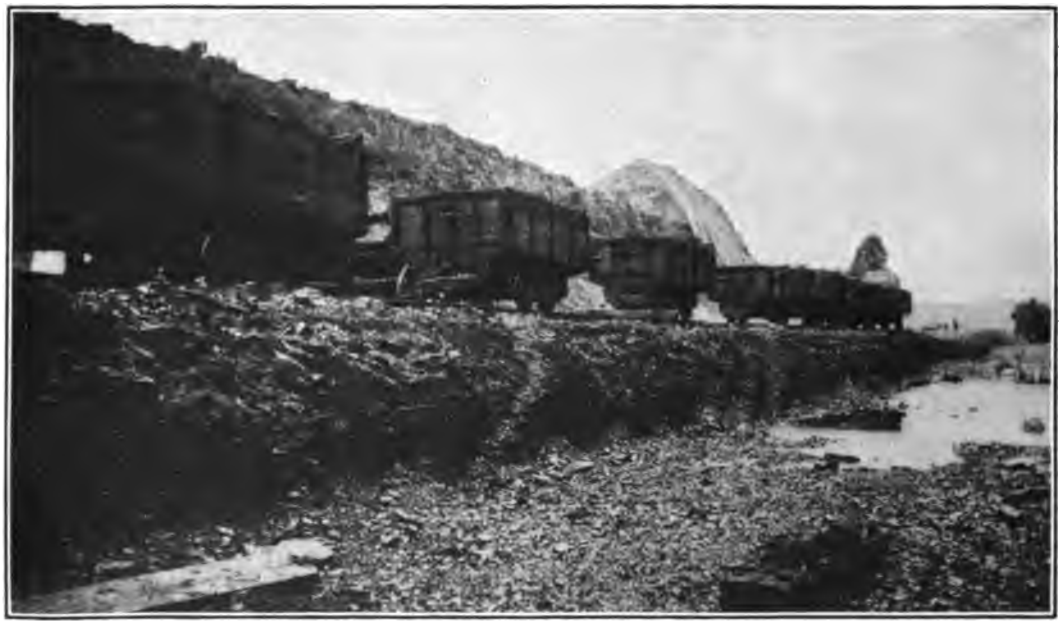
[1] Sample was slightly wet. Moisture may possibly be 1 per cent high on this account.



A. STRIPPING PITTSBURGH COAL IN JEFFERSON COUNTY, OHIO, WITH A STEAM SHOVEL.



B. SAME STRIP PIT AS SHOWN IN *A* AFTER OVERBURDEN HAS BEEN REMOVED.

238 feet above the Ames limestone. At Brilliant this limestone is 5 feet thick and was formerly burned for lime. It is well shown at many places along the Ohio Valley in the southern part of this county and at Portland lies 197½ feet below the Pittsburgh coal and 75 feet above the railroad tracks.

The Pittsburgh coal is mined by stripping with a steam shovel on the ridge about 2 miles west of Rush Run. (See Pl. VIII, *A*, *B*.) On the average about 25 feet of shale overburden is removed. The coal, 5 feet thick, is then shot and loaded on cars with a smaller steam shovel. This bed is stripped at Witch Hazel also, and preparations are under way for work of this kind at two other places in the county.

Harrison County.—The Pittsburgh coal bed underlies the hills and ridges in the eastern half of Harrison County, but its larger areas are restricted to the southeastern townships—Short Creek, Green, Cadiz, and Athens. Everywhere it is high in the hills; even in the southeast corner of the county, where it is lowest, it is approximately 175 feet above the valley. Shipping mines are few and are restricted to two townships. Everywhere the coal bed has the structure characteristic of the Pittsburgh bed in the type locality, and it is everywhere of workable thickness.

Section of Pittsburgh coal bed in mine on S. P. Dunlap farm, northwest corner of Short Creek Township, Harrison County, Ohio.

[See fig. 37, B.]

	Ft.	in.
Coal, roof, reported	2	0
"Draw slate," reported thickness	1	2
Coal, breast	2	1
Parting		½
Coal, bearing-in		2½
Parting		¾
Coal, brick and bottom	1	10½
	7	5¼

A proximate analysis of a sample from this mine shows moisture 6.5, volatile matter 35.5, fixed carbon 51.3, and ash 6.7 per cent; an ultimate analysis gives carbon 70.49, hydrogen 5.70, oxygen 13.66, nitrogen 1.22, sulphur 2.19, and ash 6.74 per cent. The heat value is 12,710 B. t. u.

A mine in the northeast part of Short Creek Township shows 4 feet 6 inches of coal with a heat value of 12,890 B. t. u. Athens Township, which lies west of Short Creek Township, forms the divide between east-flowing and west-flowing streams, and hence has a large area of coal.

Section of Pittsburgh coal bed in mine on John Edwards farm, NE. ¼ sec. 1, Athens Township, Harrison County, Ohio.

	Ft.	in.
Coal, roof		10
Clay, "Draw slate"		10
Coal, breast	2	0
Coal, bearing-in (coal and shale)		2
Coal, brick	1	3
Shale		¼
Coal, bottom	1	½
Clay.		
	6	1¾

A proximate analysis of a sample from this mine shows moisture 6, volatile matter 34.3, fixed carbon 53.7, and ash 6 per cent; an ultimate analysis gives carbon 72.22, hydrogen 5.44, oxygen 13.71, nitrogen 1.31, sulphur 1.35, and ash 5.97 per cent. The heat value is 12,960 B. t. u.

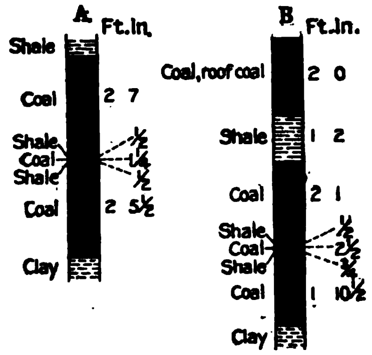


FIGURE 37.—Sections of Pittsburgh (No. 8) coal bed in Ohio. A, Warren Township, Jefferson County; B, Short Creek Township, Harrison County.

Although this section shows only 4 feet 3¾ inches of coal, excluding the roof, the quality is good and the township will become in the near future a large producer. The Meigs Creek coal bed, in good thickness and quality, is also present where due.

Cadiz Township lies north of Athens and has the Pittsburgh coal bed only in the hills and ridges. The coal is worked on several farms, but nowhere for railroad shipment.

Section of Pittsburgh coal bed in Glover Coal Co.'s mine, Cadiz, Ohio.

	Ft.	in.
Shale.		
Coal, breast:		
Coal		7
Pyrite, often wanting		$\frac{3}{8}$
Coal	1	6
Shale, very thin.		
Coal, bearing-in		2
Shale, very thin.		
Coal, brick	1	3
Shale		$\frac{1}{4}$
Coal, bottom	1	1
	4	$7\frac{5}{8}$

A proximate analysis of a sample from this mine shows moisture 3.8, volatile matter 36.7, fixed carbon 48.6, and ash 10.9 per cent; an ultimate analysis gives carbon 67.70, hydrogen 5.09, oxygen 10.68, nitrogen 1.27, sulphur 4.38, and ash 10.88 per cent. The heat value is 12,360 B. t. u.

The coal bed in Green and German townships has the characteristic Pittsburgh structure and is about 4 feet thick. The outlying hills and ridges contain a supply of coal that is valuable for farmers, as railroads are in places miles distant.

Guernsey and Noble counties.—The area of Pittsburgh coal in Guernsey and Noble counties is small and is practically restricted to the two ridges north and south of Leatherwood Creek. In the ridge just north of Quaker City C. N. Brown found the coal bed 190 feet above the Ames limestone and measured the following section:

Section of Pittsburgh coal bed north of Quaker City, Ohio.

	Ft.	in.
Coal, shaly, rejected in mining		$3\frac{1}{2}$
Coal, breast		10
Shale and pyrite		$\frac{3}{4}$
Coal, brick	1	8
Clay		$\frac{3}{4}$
Coal, bottom	1	4
Clay.		
	4	3

It will be noted that the bed has the characteristic section of the Pittsburgh bed, except that the "bearing-in" coal is represented by a thin layer of shale and pyrite. The "breast" coal, however, is abnormally thin as compared with the type section but has about the thickness that prevails along the extreme western border of the field.

In Noble County the area of Pittsburgh coal of workable thickness is very small and is limited to the northeast quarter of Beaver Township, where in a few places it is mined by farmers.

Muskingum County.—The Pittsburgh coal is found in the high hills in the southeast part of Muskingum County, where in places it attains a thickness of 30 inches and is divided into two parts by a few inches of clay or shale. It can never be a source of fuel except for local purposes.

Monroe County.—The Pittsburgh coal outcrops in the northwest part of Monroe County but appears to be too thin to mine west of sec. 24, Malaga Township.

The coal is known to be present in the southern part of Belmont County and in West Virginia, as far south at least as Proctor, where the bed is nearly 6 feet thick. This indicates that the coal is probably present in the northeastern part of Monroe County, and in fact it has been reported by many oil drillers, and what is more important, by diamond-drill tests.

Thicknesses of coal penetrated by diamond drill in northeastern Monroe County, Ohio.

	Ft.	in.
Sunsbury Township, sec. 35	5	0
Switzerland Township, sec. 28	5	3
Salem Township, sec. 32	5	8

The Pittsburgh coal is probably present in workable thickness north of a line drawn from sec. 24, Malaga Township, through Woodsfield to Proctor on Ohio River, but coal lands in this area should never be purchased without careful exploration with the drill.

AREA BETWEEN BELMONT AND FEDERAL CREEK FIELDS.

The Pittsburgh coal bed between the Belmont and Federal Creek fields is generally less than a foot thick and in places is represented by a black streak only. As already stated, the Belmont field extends into the northeast corner of Noble County, but elsewhere in this county the coal bed is thin and probably worthless. In Meigsville Township, Morgan County, it attains a maximum thickness of 2 feet 6 inches and 18 inches in Bristol and Bloom townships; southwest of Muskingum River it is thinner and is usually represented by nothing more than a black streak, until the

Federal Creek field is reached. In northern Washington County the Pittsburgh coal ranges usually from 2 to 2½ feet in thickness in an area lying mainly in Salem Township (where it is at its best) and in Liberty and Ludlow townships. It is known locally as the Salem or Limestone coal. It has been mined to a very small extent by farmers, but can never be an important source of fuel.

FEDERAL CREEK FIELD.

The Federal Creek field lies in Homer and Marion townships, in the southwest corner of Morgan County, and in Ames, Berne, and Rome townships, in the northeast part of Athens County. Under cover the coal bed extends for an undetermined distance over the line into Washington County. The length of the field above drainage is approximately 15 miles in a northwest-southeast direction, and its average width less than 3 miles. The field is drained by Federal Creek, and the topography is rough. Eastward and westward the coal bed thins abruptly and becomes worthless.

The section of the bed is markedly different from that in the Belmont field. It consists usually of two prominent benches separated by a thick layer of clay. Each bench usually contains one or more shale partings, and the top bench commonly has from a few inches to a foot or even more of bony coal. These characters are well shown in the sections below.

Section of Pittsburgh coal bed in Waymer mine near Joy, Ohio.

[See fig. 38, A.]

	Ft.	in.
Coal, upper bench:		
Coal	1	6
Coal, bony		8
Clay		11
Coal, lower bench:		
Coal		2
Parting		⅛
Coal		7½
Parting		½
Coal		3
Parting		⅜
Coal		1½
Parting		⅜
Coal	2	0
	6	4⅜

A proximate analysis of a sample from this mine shows moisture 6.9, volatile matter 40.5, fixed carbon 44.4, and ash 8.2 per cent; an ultimate analysis shows carbon 67.39, hydrogen 5.32, oxygen 13.98, nitrogen 0.90, sulphur 4.22, and ash 8.19 per cent. The heat value is 12,100 B. t. u.

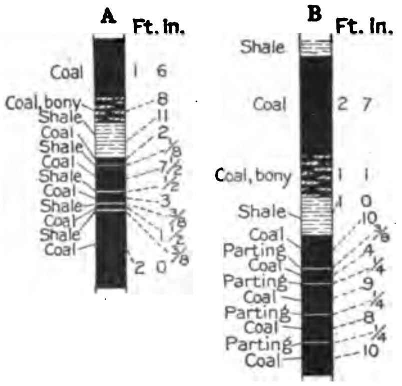


FIGURE 38.—Sections of Pittsburgh (No. 8) coal bed in Ohio. A, Homer Township, Morgan County; B, Berne Township, Athens County.

Section of Pittsburgh coal bed in Black Diamond Coal & Coke Co.'s mine, Lathrop, Ohio.

[See fig. 38, B.]

	Ft.	in.
Shale.		
Coal, upper bench:		
Coal	2	7
Coal, bony	1	1
Clay	1	0
Coal, lower bench:		
Coal		10
Parting		⅜
Coal		4
Parting		¼
Coal		9
Parting		¼
Coal		8
Parting		¼
Coal		10
Clay.		
	8	2⅛

A proximate analysis of a sample from this mine shows moisture 5.8, volatile matter 37.4, fixed carbon 48.8, and ash 8 per cent; an ultimate analysis gives carbon 67.55, hydrogen 5.14, oxygen 14.17, nitrogen 0.95, sulphur 4.19, and ash 8 per cent. The heat value is 12,300 B. t. u.

Section of Meigs Creek coal bed in Malden mine, Barnesville, Ohio.

[See fig. 44, B.]

	Ft.	in.
Shale and coal, "roof coal"	1	0
Shale and clay	1	10
Coal		7½
Pyrite		¼
Coal		11½
Shale		¼
Coal	2	1½
	6	7

A proximate analysis of a sample from this mine shows moisture 4.5, volatile matter 35.3, fixed carbon 47.1, and ash 13.1 per cent; an ultimate analysis shows carbon 65.83, hydrogen 4.99, oxygen 11.71, nitrogen 1.13, sulphur 3.27, and ash 13.07 per cent. Its heat value is 12,010 B. t. u.

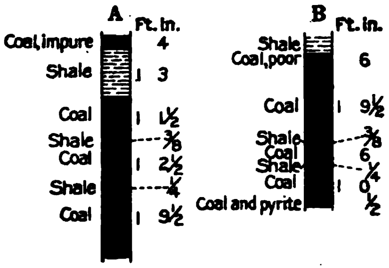


FIGURE 45.—Sections of Meigs Creek (No. 9) coal bed in Belmont County, Ohio. A, Flushing; B, Barnesville.

The bed in this mine ranges from 3 feet 8 inches to 4 feet 3 inches in thickness and contains thin discontinuous partings of shale or pyrite. The coal has long been mined by farmers as the Upper Barnesville bed. Goshen Township, east of Warren Township, appears to be underlain by the Meigs Creek bed except in two small areas where streams have removed it. A measurement in the Statler mine, in the NE. ¼ sec. 36, shows 4 feet of coal whose heat value is 11,840 B. t. u. Union Township, north of Goshen, is almost wholly underlain by the Meigs Creek coal bed. In the Calbert mine, in the SE. ¼ sec. 25, the bed is 4 feet 4 inches thick and has a heat value of 12,600 B. t. u. In another mine in this township the section shown in figure 45, A, was measured. The coal is hard and bright but here and there contains streaks of shale or bony coal. The mine supplies the neighborhood farmers and also several mills at Belmont and Bethesda. Richland Township, east of Union, appears to be underlain by the Meigs Creek coal, except where the bed is cut out along McMahon and Wheeling creeks and their tributaries. The coal has been mined in a small way by several farmers. It shows well in the railroad cut at Glencoe, where it is about 85 feet above the Pittsburgh coal and measures approximately 4 feet in thickness. Another section is shown in figure 46, A. Smith Township, which lies south of Richland, is underlain by Meigs Creek coal except in a very small area in the extreme northeastern corner.

Section of Meigs Creek coal bed in Armstrong's mine, near Glencoe, Ohio.

[See fig. 45, B.]

	Ft.	in.
Shale.		
Coal, not mined		6
Coal	1	9½
Shale		⅜
Coal		6
Shale		¼
Coal	1	0
Coal and pyrite		½
	3	10⅝

A proximate analysis of a sample from this mine shows moisture 3.5, volatile matter 34.8, fixed carbon 49.9, and ash 11.8 per cent; an ultimate analysis shows carbon 67.36, hydrogen 5.02, oxygen 11.06, nitrogen 1.05, sulphur 3.67, and ash 11.84 per cent. The heat value is 12,390 B. t. u.

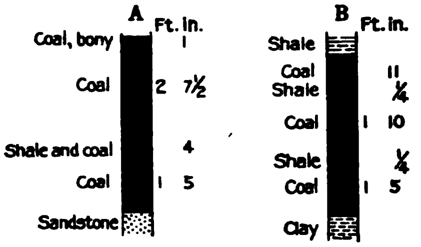


FIGURE 46.—Sections of Meigs Creek (No. 9) coal bed in Ohio. A, Richland Township, Belmont County; B, Athens Township, Harrison County.

The floor in this mine is uneven, and hence the thickness of the bed varies considerably. Thin, discontinuous partings of shale and pyrite are common. Pultney Township, which lies east of Richland, fronts on Ohio River and has been deeply trenched by McMahon Creek and its leading tributaries. The local bed has been opened on several farms and in sec. 5 is reported to be 4 feet thick. Mead Township, south of Pultney, is underlain by the Meigs Creek coal bed except along Pipe and

Wegee creeks, where the coal has been removed by erosion.

Section of Meigs Creek coal bed in McMillen mine, NW. ¼ sec. 32, Mead Township, Belmont County, Ohio.

	Ft.	in.
Clay	3	0
Coal, not mined		4
Coal	4	5
Shale.		
	7	9

The southern tier of townships appears to contain the Meigs Creek coal wherever due, but the bed is generally below drainage. In Somerset Township the bed ranges from 2 feet 6 inches to 4 feet in thickness and has been mined to a small extent by farmers. Along Captina Creek in Wayne, Washington, and York townships the coal is above drainage, except from the east part of Wayne to a point near the middle of Washington Township. The coal is said to have been mined in a disconnected way in the vicinity of Armstrongs Mills for more than 60 years and to range in thickness from 2 to 4½ feet. About 1½ miles south of the Belmont County line the coal is said to lie in the bed of Ohio River and to have been mined by stripping during low water.

From the preceding paragraphs it is apparent that the Meigs Creek bed contains a large tonnage of coal in Belmont County. Thus far it has been worked only in a small way, because those who were prepared to operate on a commercial scale have much preferred the thicker and better Pittsburgh bed, which lies only a short distance below.

The Meigs Creek bed, however, may be regarded as a fuel reserve which will be eagerly developed when the Pittsburgh bed is a thing of the past. The coal is of fair quality. Its sulphur content rarely equals 4 per cent and in one analysis made by the Ohio Geological Survey it is less than 2 per cent. The ash is high, reaching in some samples as much as 15 per cent and in few is as low as 10 per cent. The heat value usually ranges between 11,700 and 12,600 B. t. u. The average of seven analyses of samples taken in different parts of the county shows ash 12.2, sulphur 2.99, and moisture 4.6 per cent; the heat value is 12,140 B. t. u. and the moisture in air-dried samples is about 3 per cent.

Harrison County.—The Meigs Creek coal bed is present in only three townships in the southeast part of Harrison County—Short Creek, Athens, and Cadiz. In Cadiz Township it occurs in so small an area that it may be neglected. In Athens Township the acreage is large and the coal has been made accessible by numerous streams which cut through it.

Section of Meigs Creek coal bed in Joshua Kirk mine, 1 mile west of New Athens, Ohio.

[See fig. 46, B.]

	Ft.	in.
Shale.		
Coal		11
Parting		¼
Coal	1	10
Parting		¼
Coal	1	5
Clay.		
	4	2½

A proximate analysis of a sample from this mine shows moisture 5.3, volatile matter 33.1, fixed carbon 51.3, and ash 10.3 per cent; an ultimate analysis gives carbon 68.67, hydrogen 5.21, oxygen 12.38, nitrogen 1.25, sulphur 2.20, and ash 10.29 per cent. The heat value is 12,340 B. t. u.

Section of Meigs Creek coal bed in Culberson mine, south of New Athens, Ohio.

	Ft.	in.
Shale and impure coal	2	0
Clay	1	8
Coal, bony, rejected in mining		2
Coal, top	2	11
Shale		¼
Coal, bottom	1	4
Clay	2	0
	10	1¼

An average thickness of 4 feet 6 inches is claimed for the coal bed in this mine. Nodules of pyrite are common and are sorted out by the miners. This coal has been mined on many farms for local use.

The Meigs Creek coal bed underlies practically all of the southern half of Short Creek Township and, as the Pittsburgh coal is below drainage, is an important source of fuel for the farmers.

Section of Meigs Creek coal bed on Lodge farm, in sec. 16, Short Creek Township, Harrison County, Ohio.

	Ft.	in.
Shale	3	0
Coal	2	9
Shale, in places absent.		
Coal	1	3
	7	0

Bedford Township the bed is less than 2 feet thick, as shown in figure 42, B, but it expands in a short distance to the south and has long been mined on a large scale at Pomeroy. It was early used in the salt furnaces and was later shipped by river and still later by rail.

Although the Pomeroy coal is of workable thickness in Meigs, Gallia, and Lawrence counties, it is thickest in Meigs, in which all the railroad mines, with one exception, are situated. The thickness of the bed and the quality of the coal are shown in figure 41, B, and also in the following section:

Section of Pomeroy coal bed in Logan mine at Pomeroy, Ohio.

	Ft.	in.
Coal, bony	1	3
Coal	1	8
Parting, very thin.		
Coal		3
Parting, very thin.		
Coal	2	3
Clay.		
	5	5

A proximate analysis of a sample from this mine shows moisture 7.2, volatile matter 32.8, fixed carbon 50.7, and ash 9.3 per cent; an ultimate analysis gives carbon 66.47, hydrogen 5.39, oxygen 16.43, nitrogen 1.10, sulphur 1.32, and ash 9.29 per cent. The heat value is 12,000 B. t. u.

Section of Pomeroy coal bed in Maynard Bros.' mine, near Rutland, Ohio.

[See fig. 41, A.]

	Ft.	in.
Shale.		
Coal, top		6
Coal, impure		7
Coal		3
Parting		¼
Coal	1	0
Parting		1
Coal		1
Parting		⅜
Coal	1	3
Coal, splint		2¾
Coal	2	4
Clay.		
	6	4⅜

A proximate analysis of a sample from this mine shows moisture 7.6, volatile matter 33.4, fixed carbon 48.1, and ash 10.9 per cent, and an ultimate analysis gives carbon 65.29, hydrogen 5.20, oxygen 15.72, nitrogen 1.03, sulphur 1.83, and ash 10.93 per cent. Its heat value is 11,720 B. t. u. The average of five analyses gives ash 10.4, sulphur 2.46, moisture 6.5 per cent; heat value 11,950 B. t. u.; the moisture in the air-dried sample is about 4 per cent.

The coal dips below drainage on Ohio River a short distance above Pomeroy. At Syracuse it is 80 feet below the flood plain, and eastward its presence in workable thickness has been demonstrated only by the drill.

Southwest from the Pomeroy field, the coal bed thins and rises in the hills and has been extensively eroded as far as Raccoon Creek in Gallia County. Throughout this area the coal is commonly 2 to 4 feet thick, as shown in figure 43, A, and has been mined in a small way on many farms. South of Raccoon Creek the Pomeroy coal has been less eroded and underlies a large part of the extreme southern area of Gallia County and the adjacent part of Lawrence County. Its western limit is on Greasy Ridge in the eastern part of Lawrence County, where it attains a thickness of 5 feet, as shown in figure 43, B, and is an important source of fuel among the farmers. East of Greasy Ridge the coal attains in places a thickness of 2 feet to 3 feet 6 inches, but throughout most of the territory it is thinner and at present is of no value. Manifestly the Pomeroy coal in its southwest extension can never be more than a source of fuel for the residents of that region.

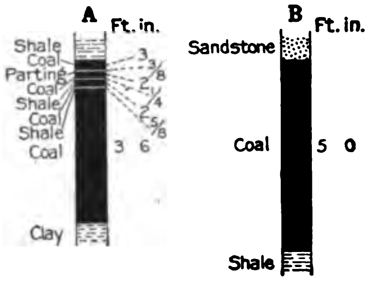


FIGURE 43.—Sections of Pomeroy (No. 8a) coal bed in Ohio. A, Cheshire Township, Gallia County; B, Mason Township, Lawrence County.

MEIGS CREEK (NO. 9) COAL BED.

General features.—The Meigs Creek (No. 9) coal, the highest of the important beds in the geologic column of Ohio, was named by C. N. Brown from a stream in Morgan County that drains an area in which this coal bed is well developed. It lies 80 to 100 feet above the Pittsburgh coal and is therefore easily identified. The Sewickley bed of Pennsylvania and West Virginia is its equivalent.

Although the Meigs coal bed is due all the way from Jefferson County southwest to Gallia

U. S. GEOLOGICAL SURVEY

MAP

coal. Bristol Township, which lies west of Manchester Township, has thousands of acres of Meigs Creek coal beneath its hills and ridges. One test shows 4.3 per cent sulphur and 12,110 B. t. u. The thickness of the coal bed, where tested (see fig. 48, B), is 3 feet 9½ inches, exclusive of partings. A measurement made on the A. E. Smith farm in sec. 25 shows 5 feet 4 inches of coal in three benches, of which the thickest (10 inches) was not mined. Meigsville Township lies south of Bristol and contains a large area of the Meigs Creek coal.

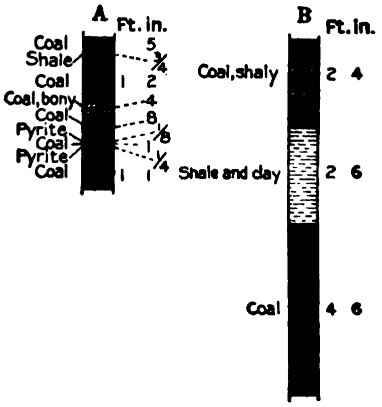


FIGURE 49.—Sections of Meigs Creek (No. 9) coal bed in Ohio. A, Meigsville Township, Morgan County; B, Aurelius Township, Washington County.

Section of Meigs Creek coal bed in F. S. Murray mine, sec. 20, Meigsville Township, Morgan County, Ohio.

[See fig. 49, A.]

	Ft.	in.
Clay.		
Coal, usually about 5 inches thick		1¼
Shale		¾
Coal, "smut" streak near middle	1	2
Coal; bony		4
Coal		8
Pyrite		⅛
Coal		1
Pyrite		¼
Coal	1	1
	3	6⅜

A proximate analysis of a sample from this mine shows moisture 5.1, volatile matter 36.1, fixed carbon 47.1, and ash 11.7 per cent; an ultimate analysis gives carbon 64.77, hydrogen 5.06, oxygen 12.67, nitrogen 0.87, sulphur 4.89, and ash 11.74 per cent. The heat value is 11,930 B. t. u.

Center Township forms the southeast corner of the county and contains a larger area of Meigs Creek coal than any other township in the county. The bed usually ranges from 2 feet 6 inches to 4 feet 4 inches in thickness and is divided into two benches, separated by 1 to 6 inches of shale or impure coal. Both floor and roof are irregular, and the thickness of the bed changes abruptly. Windsor Township, north of Muskingum River, appears to be underlain by a solid block of coal 3 feet to 3 feet 6 inches thick. An average of three analyses from samples taken in different townships shows ash 10.9, sulphur 4.75, and moisture 4.8 per cent. The heat value is 12,080 B. t. u.

Washington County.—In Washington County the Meigs Creek coal bed is present, under a large area between Muskingum and Little Muskingum rivers and north of Cow Run. It is believed to be of workable thickness throughout nearly this area and at three places outside of it—in the valley of Cow Run; a short distance west of Newport, where the Burning Springs anticline brings it far above drainage; and in the extreme southeast corner of the county. The areas of coal in these three places, however, are small and can never be of more than local value.

The Meigs Creek coal bed has been given several names in Washington County, and some people are still confused as to its position. Both the coal bed and the Ames limestone are well shown along the valley of Duck Creek, a short distance north of the Washington County line, and the coal can be followed down this valley to the point where it passes below drainage at the mouth of Cow Run. The position of the coal with reference to the Ames limestone proves it to be the Meigs Creek bed beyond a reasonable doubt. The coal bed is thickest and most persistent in the townships along the northern border of the county and is there a valuable bed which will, some day, be the basis of important mining operations, though at present it is worked for local market only.

Aurelius, the northernmost township in the county, contains a large acreage of Meigs Creek coal, though much has been swept away by Duck Creek. Formerly the fuel was mined for shipment by rail at Macksburg, but the practice was discontinued many years ago.

Section of Meigs Creek coal bed on Charles Schimmel's land, sec. 28, Aurelius Township, Washington County, Ohio.

	Ft.	in.
Coal, lower part only of upper bench		9½
Shale and clay	1	3
Coal		8
Shale		⅝
Coal	2	3¼
	5	⅜

A proximate analysis of a sample from this mine shows moisture 3.4, volatile matter 37.9, fixed carbon 49.1, and ash 9.6 per cent; an ultimate analysis gives carbon 68.33, hydrogen 5.31, oxygen 10.85, nitrogen 0.90, sulphur 5.03, and ash 9.58 per cent. The heat value is 12,750 B. t. u.

Section of Meigs Creek coal bed on A. F. Wooster's land, in valley of Duck Creek, Aurelius Township, Washington County, Ohio.

	Ft.	in.
Coal	2	6
Shale	1	3
Coal	2	10
	6	7

Another section of the Meigs Creek coal bed in Aurelius Township is shown in figure 49, B.

Salem Township, which lies south of Aurelius, is crossed by the deep valley of Duck Creek. The coal appears to be present in this township wherever it is due and to be of good thickness. It has been worked on many farms and is the local source of fuel among the residents. Along Bear Creek, in the southwest part of the township, the coal bed measures 4 to 5 feet and is almost free from partings. East of Duck Creek, in this township, the bed is thick and is divided into two benches by a thick bench of shale or clay.

Section on Twiggs farm on Pawpaw Creek, Salem Township, Washington County, Ohio.

	Ft.	in.
Coal	2	6
Shale	1	0
Coal	3	0
	6	6

The coal is thinner in the southern part of the township, where it measures about 4 feet; over the line in Fearing Township it is still thinner and is probably worthless.

The Meigs Creek coal is well developed in the parts of Waterford and Adams townships east of Muskingum River, where it usually ranges from 2 to 4 feet in thickness and is divided into two parts by a thick bed of shale or clay. The best known mine is at Coal Run, on Muskingum River. It has been worked discontinuously for 25 years and supplies many farmers and occasionally ships a barge load to Marietta.

Section of Meigs Creek coal bed in the Felix mine at Coal Run, Washington County, Ohio.

	Ft.	in.
Clay.		
Coal		6
"Smut" streak		⅜
Coal	1	4
Coal, pyrite and shale		3¾
Coal, with two pyrite streaks		11¾
Coal, forming floors in entries		4
	3	5⅞

A proximate analysis of a sample from this mine shows moisture 2.9, volatile matter 37.5, fixed carbon 46.7, and ash 12.9 per cent; an ultimate analysis gives carbon 65.88, hydrogen 5.05, oxygen 9.71, nitrogen 0.92, sulphur 5.55, and ash 12.89 per cent. The heat value is 12,250 B. t. u.

In Liberty Township and the northwest part of Ludlow the coal bed has a good thickness and is well exposed along Campbells Run and Pawpaw Creek. The following measurement was made in a cut at Germantown:

Section of Meigs Creek coal bed at Germantown, Ohio.

	Ft.	in.
Coal	2	6
Clay	1	6
Coal	3	0
	7	0

The lower bench appears to be the better in quality, though both are mined.

Section on McCurdy farm, in the NW. ¼ sec. 34, Ludlow Township, Washington County, Ohio.

	Ft.	in.
Coal	2	2
Clay	1	0
Coal	2	4
	5	6

The coal bed thins abruptly to the north in Ludlow Township, and on the Payne farm in sec. 16 it measures only 8 inches. The quantity of coal in Liberty and Ludlow townships is large and as yet has scarcely been touched by the miner. Like the rest of the Meigs Creek coal in Ohio it forms a large fuel reserve for future generations.

be eagerly sought when the underlying Pittsburgh and Meigs Creek coals have been exhausted. Two or three western States are now mining coals for railroad shipment that are not thicker and apparently are not superior in quality to the Uniontown. This coal is mined by farmers along Sunfish Creek and probably at several other places in Monroe County.

The Waynesburg coal, which forms the summit of the Monongahela formation, is of very little value as a source of fuel. Its thickness varies and it is only in small areas that it is workable. The coal is at its best in the southern part of Belmont County, where it ranges in thickness from 2 to 4 feet. Condit reports that it is mined in the vicinity of Alledonia station, at Somerton, and along Bend Fork east of Hunter. It was formerly mined on the Yocum farm near Somerton, Somerset Township, for use in a mill, but the mine was abandoned because of trouble with water. The coal is reported to be less than 3 feet thick and of poor quality. It thins to the south and in the adjacent part of Monroe County is reported worthless.

COAL BEDS OF THE DUNKARD GROUP.

The Dunkard group, formerly known as the "Upper Barren Coal Measures," is the youngest formation in Ohio and is found only in the high hills and ridges in the eastern and southern parts of the State. The group includes two formations, the Greene above and the Washington below. Orton assigned to it a thickness of 500 feet, but recent work by Stauffer increases this to 636 feet. The formation rests on the Waynesburg coal, the top member of the Monongahela formation, and extends from that bed to the tops of the highest hills and ridges.

The following section, measured by C. R. Stauffer, shows the composition of the group as exposed near Jacobsburg, Belmont County:

Section of Dunkard group and upper part of the Monongahela formation in Belmont County, Ohio.

	Ft.	in.
Dunkard group:		
Shale, gray, to top of hill back of barn on A. R. Kelsey's farm	12	8
Sandstone, rather massive, micaceous, gray, passing into shale	3	8
Shale, gray	17	2
Shale, black to bluish, resembling a coal blossom; contains plant fragments	2	10
Limestone, clayey, gray; weathers rapidly	3	1
Shale, blue to drab, soft	1	4
Limestone, gray, containing ostracodes	..	9
Shale, gray, with some limestone nodules		11
Limestone, nodular, gray	1	3
Shale, soft, gray, with numerous calcareous nodules	11	0
Sandstone, thin bedded, gray	2	0
Shale, soft, fissile, gray	11	6
Limestone, drab, in thin layers, with calcareous shale between; fossiliferous; Upper Washington limestone member	3	0
Shale, soft, clayey, red and gray	21	4
Concealed (aneroid reading)	10	0
Sandstone, gray	1	4
Concealed (aneroid reading)	16	0
Sandstone, thin, cross-bedded	4	0
Shale, soft, gray	20	0
Limestone, compact drab and clayey gray shale; lower layer nodular; fossiliferous; Middle Washington limestone member	6	10
Shale, gray and red, with several thin coal blossoms and nodules of sandstone	25	4
Coal, Washington	4	6
Shale, greenish gray to buff, with a few concretionary nodules	17	6
Sandstone, micaceous, gray	5	10
Shale, micaceous, sandy, gray	5	10
Sandstone, gray to yellowish, micaceous, laminated	13	8
Shale, gray to buff, containing some small iron nodules	19	0
Sandstone, micaceous, gray	1	5
Shale, sandy, gray to buff, micaceous	12	2
Sandstone, gray, laminated, micaceous	2	9
Shale, fissile, gray	9	10
Sandstone, micaceous, gray	1	10
Shale, gray to buff, sandy	8	10
Limestone, blue, shaly, containing ostracodes; Elm Grove limestone member	1	4
Shale, gray	2	0
Monongahela formation:		
Coal, Waynesburg, upper bench	1	0
Shale, gray to drab, sandy, micaceous	2	9
Sandstone, gray, cross-bedded and in places shaly, micaceous; contact with coal below irregular	5	8
Coal, Waynesburg, lower bench	1	6
Level of Ohio River & Western Railway at School No. 12.		
	293	5

Concerning the rocks of the Dunkard, Stauffer writes:

> A large part of the Dunkard in Ohio is to be classed as red beds, although the Monongahela formation and even the Conemaugh are not without their red shales, which in the Monongahela are often so like those of the Dunkard as to make them easily confused if it were not for other rather easily identified strata associated therewith. There are but few really red sandstones and those usually only coated red on the outside or weathered surface in the Dunk-

ard formation of Ohio. The red is thus almost confined to the shale. In the northern part of the Dunkard area the red beds are to be found chiefly in the upper part of the formation, but to the southward most of the shale in the whole formation is red. In the main these shales, sandstones, limestones, and beds of coal represent land, swamp, and fresh-water deposits, but the presence of gypsum in certain of the shales and sandstones and again marine or brackish-water fossils in other beds indicates that these conditions at times gave place to others of a very different character.

From the economic standpoint the shales and sandstones occupy the place of most importance both now and for the future. The shales are being utilized, at Marietta, in the manufacture of brick, while in the same general locality three or four of the sandstones are extensively used in the manufacture of grindstones.

The coals of the Dunkard have little or no value in Ohio. The principal beds are the Waynesburg “A,” Washington, Washington “A,” Jollytown, Dunkard, and Nineveh, but these are in many places represented by streaks only, and not one of them is regularly mined in Ohio. Near Alledonia, Belmont County, the Waynesburg “A” coal is 18 inches thick and has been worked in a few places by farmers. The Washington is the best developed and most persistent coal bed in the Dunkard. It measured over 7 feet in the deep cut on the Colerain pike above Martins Ferry but is impure and can not be marketed under existing conditions. This coal is found elsewhere in Belmont County and in places in Monroe and Washington counties. Farmers have tested it at many places but have always been disappointed.

COMPOSITION OF OHIO COALS.

The following tables showing the composition of Ohio coals were compiled from Bulletin 9 of the Ohio Geological Survey and from recent publications of the United States Geological Survey and Bureau of Mines.

The samples were cut under the same general conditions, which are those prescribed by the United States Geological Survey. It is believed, therefore, that comparisons can safely be made and that the figures are a fair representation of the composition of Ohio coals.

In the “Reference” column “Ohio” refers to the Geological Survey of Ohio, “Mines” to the United States Bureau of Mines, and “U.S.G.S.” to the United States Geological Survey.

Analyses of Ohio coals.

[Made by Ohio Geological Survey, U. S. Bureau of Mines, and the United States Geological Survey.]

Sharon coal (No. 1).

County.	Township.	Mine or laboratory number.	Proximate.			Ultimate.						British thermal units.[1]	Reference.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Organization.	Bull. No.
Jackson	Liberty	15188	13.6	31.8	50.4	4.2	0.86					11,680	Mines	
Do	do	15189	12.8	31.5	47.9	7.8	.97					11,270	do	

Quakertown coal (No. 2).

County.	Township.	Mine or laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	British thermal units.[1]	Organization.	Bull. No.
Jackson	Milton		9.3	33.0	54.2	3.5	1.25					12,530	Ohio	

Clarion coal (No. 4a).

County.	Township.	Mine or laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	British thermal units.[1]	Organization.	Bull. No.
Lawrence	Decatur	65	6.3	35.3	41.0	17.41	5.29	4.91	57.92	1.07	13.40	10,740	Ohio	9
Do	do	67	5.9	37.2	41.6	15.28	5.36	5.06	60.22	1.18	12.90	11,130	do	9
Do	do	68	6.1	38.5	45.5	9.94	3.61	5.42	65.53	1.22	14.28	11,960	do	9
Do	Washington	66	6.0	39.1	43.0	11.86	5.10	5.26	63.32	1.22	13.24	11,730	do	9
Scioto	Bloom	64	6.8	37.9	46.0	9.34	3.45	5.33	65.30	1.23	15.35	11,760	do	9
Jackson	Madison	63	4.9	35.7	45.7	13.70	6.14	4.89	62.57	1.23	11.47	11,500	do	9
Do	Bloomfield	62	5.3	37.4	43.8	13.54	6.08	4.98	62.05	1.23	12.12	11,380	do	9
Do	Milton	55	5.6	38.9	47.4	8.09	3.70	5.47	67.30	1.28	14.16	12,280	do	9
Do	do	56	5.0	39.7	45.5	9.80	4.08	5.39	66.14	1.28	13.31	12,150	do	9
Do	do	57	4.7	40.5	46.2	8.61	3.73	5.44	67.51	1.26	13.45	12,360	do	9
Do	do	60	5.3	41.0	45.3	8.40	3.72	5.50	66.52	1.28	14.58	12,210	do	9
Do	do	1896	8.4	41.3	43.6	6.7	3.10					12,250	U.S.G.S.	290
Do	do	1897	7.5	39.3	42.7	10.5	5.44						do	290
Vinton	Wilkesville	59	4.7	39.9	44.2	11.21	4.16	5.36	65.04	1.28	12.95	12,050	Ohio	9
Do	do	61	4.5	40.1	46.5	8.85	4.23	5.44	67.17	1.28	13.03	12,340	do	9
Do	do	2208	6.8	40.0	45.5	7.7	3.34					12,510	U.S.G.S.	290
Do	do	2209	7.4	41.6	44.8	6.2	2.77						do	290
Do	Vinton	54	5.0	40.3	46.5	8.21	2.81	5.49	68.52	1.28	13.69	12,470	Ohio	9
Do	do	58	4.6	41.4	42.9	11.10	5.28	5.36	64.91	1.30	12.05	12,050	do	9
Do	Madison	70	5.0	39.9	46.1	8.97	3.32	5.48	67.92	1.33	12.98	12,530	do	9
Do	Elk	69	4.9	39.2	46.6	9.32	3.53	5.40	67.17	1.30	13.28	12,450	do	9

[1] British thermal units may be reduced to pound calories by multiplying by 0.5556 and to French calories by multiplying by 0.252.

Analyses of Ohio coals—Continued.

Lower Kittanning coal (No. 5).

County.	Township.	Mine or laboratory number.	Proximate.				Ultimate.				British thermal units.	Reference.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Organization.	Bull. No.
Lawrence	Perry	74	7.6	38.5	45.1	8.79	3.20	5.59	66.71	1.27	14.44	12,200	Ohio	9
Do	Elizabeth	75	8.1	34.5	47.7	9.71	2.13	5.44	65.54	1.23	15.95	11,930	...do	9
Jackson	Milton	76	8.4	35.2	49.0	7.42	2.65	5.47	66.63	1.37	16.46	12,190	...do	9
Do	.....do	1898	9.4	36.7	46.3	7.6	4.08					11,900	U.S.G.S.	290
Do	.....do	1899	9.0	37.8	43.9	9.3	4.41						...do	290
Perry	Pike	71	6.8	35.2	47.8	10.16	4.72	5.26	64.78	1.22	13.86	11,860	Ohio	9
Do	.....do	72	6.7	37.1	49.1	7.12	2.58	5.47	68.34	1.24	15.25	12,390	...do	9
Muskingum	Washington	73	5.0	39.8	47.4	7.77	4.80	5.37	68.07	1.18	12.81	12,570	...do	9
Jefferson	Knox	77b	2.5	38.5	51.6	7.40	3.82	5.38	74.20	1.27	7.93	13,660	...do	9
Tuscarawas	Sandy	77	5.3	38.7	48.3	7.71	3.25	5.46	69.75	1.18	12.65	12,900	...do	9
Do	.....do	3968	5.6	36.3	49.4	8.7	2.89						U.S.G.S.	332
Do	.....do	3969	4.5	39.9	47.1	8.5	3.73					12,850	...do	332
Mahoning	Green	77a	5.2	36.9	53.2	4.72	2.17	5.50	73.84	1.41	12.36	13,500	Ohio	9

Middle Kittanning coal (No. 6).

County.	Township.	Mine or laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	British thermal units.	Organization.	Bull. No.
Lawrence	Perry	136	6.0	39.1	50.1	4.82	3.61	5.56	71.82	1.33	12.86	13,170	Ohio	9
Do	.....do	82a	6.6	34.3	48.2	10.92	3.32	5.16	64.95	1.23	14.42	11,930	...do	9
Gallia	Greenfield	82b	8.1	37.5	45.9	8.52	3.64	5.48	65.71	1.18	15.47	12,090	...do	9
Athens	Canaan	89a	6.4	34.2	50.9	8.49	.51	5.40	69.25	1.43	14.92	12,450	...do	9
Do	Athens	83	6.2	36.4	49.6	7.82	.90	5.43	69.22	1.30	15.33	12,360	...do	9
Do	Waterloo	84	6.7	35.4	51.2	6.75	2.28	5.49	69.21	1.18	15.09	12,460	...do	9
Do	.....do	85	6.8	36.9	48.2	8.05	2.14	5.49	67.40	1.37	15.55	12,230	...do	9
Vinton	Swan	82	4.9	39.2	45.8	10.15	4.25	5.40	66.26	1.23	12.71	12,320	...do	9
Hocking	Starr	81	6.5	38.3	47.2	8.03	3.52	5.49	67.33	1.20	14.43	12,330	...do	9
Do	Ward	7712	9.7	32.5	53.4	4.43	.54	5.70	69.50	1.25	18.58	12,450	Mines	22
Do	.....do	86	7.5	34.0	52.6	5.85	.77	5.52	70.05	1.42	16.39	12,510	Ohio	9
Do	.....do	87	7.5	35.0	52.7	4.81	.66	5.53	71.04	1.43	16.53	12,700	...do	9
Do	.....do	88	7.4	34.2	53.4	5.00	1.06	5.55	70.58	1.32	16.49	12,650	...do	9
Do	Green	80	6.5	37.3	49.2	6.97	2.57	5.45	68.40	1.18	15.43	12,420	...do	9
Athens	Dover	89	7.2	34.2	51.9	6.72	1.65	5.56	69.32	1.30	15.45	12,350	...do	9
Do	Trimble	90	7.3	32.4	53.6	6.73	.86	5.45	69.46	1.34	16.16	12,410	...do	9
Perry	Salt Lick	79	7.7	33.5	51.3	7.47	1.45	5.46	68.30	1.18	16.14	12,190	...do	9
Do	.....do	1900	10.8	34.9	48.2	6.1	1.11					11,990	U.S.G.S.	290
Do	.....do	1901	9.8	35.7	48.5	6.0	1.43						...do	290
Do	Monroe	91	6.8	35.5	51.8	5.91	1.00	5.49	70.30	1.30	16.00	12,570	Ohio	9
Do	Pike	78	7.0	37.1	48.9	6.95	2.33	5.58	68.29	1.26	15.50	12,380	...do	9
Do	.....do	92	5.2	38.9	46.0	9.86	3.43	5.38	66.05	1.18	14.10	12,190	...do	9
Do	.....do	2119	8.9	38.6	46.7	5.8	3.00					12,330	...do	290
Do	.....do	2120	8.9	39.3	47.8	4.0	1.74						...do	290
Do	Bearfield	93	5.9	36.6	47.4	10.10	4.96	5.26	65.43	1.22	13.03	12,040	...do	9
Do	Clay	95	6.7	38.3	48.4	6.64	2.43	5.61	68.45	1.29	15.58	12,430	...do	9
Do	Harrison	94	7.2	37.6	49.9	5.26	2.34	5.60	69.77	1.26	15.77	12,610	...do	9
Do	.....do	97	5.7	38.8	47.0	8.45	3.38	5.37	67.77	1.18	13.85	12,330	...do	9
Do	.....do	98	6.4	38.0	48.0	7.58	2.72	5.49	68.06	1.26	14.89	12,360	...do	9
Muskingum	Brush Creek	101	5.1	39.7	45.4	9.77	5.54	5.32	65.74	1.14	12.49	12,240	...do	9
Do	Harrison	100	4.7	40.3	45.2	9.83	4.10	5.38	67.71	1.16	11.82	12,370	...do	9
Do	Newton	96	5.0	38.2	47.2	9.56	5.97	5.29	65.88	1.12	12.18	12,160	...do	9
Do	Washington	99	5.4	39.2	46.1	9.28	3.77	5.34	67.16	1.18	13.27	12,280	...do	9
Do	Muskingum	104	5.5	40.3	49.0	5.23	3.63	5.57	70.54	1.26	13.77	12,940	...do	9
Do	Madison	102	4.7	39.9	46.1	9.28	5.35	5.35	66.69	1.28	12.05	12,340	...do	9
Do	.....do	103	4.6	41.0	47.8	6.58	4.49	5.47	69.58	1.30	12.58	12,830	...do	9
Coshocton	Linton	111	4.4	40.9	49.3	5.36	3.61	5.56	71.34	1.28	12.85	13,050	...do	9
Do	.....do	112	10.9	34.0	48.5	6.64	2.03	5.37	63.08	1.15	21.73	11,040	...do	9
Do	Franklin	108	4.3	41.1	49.0	5.59	4.00	5.41	71.42	1.22	12.36	13,080	...do	9
Do	Virginia	109	5.1	39.0	48.9	7.02	3.87	5.45	69.49	1.20	12.97	12,720	...do	9
Do	Jackson	105	5.3	40.9	47.5	6.30	4.22	5.50	69.29	1.24	13.45	12,760	...do	9
Do	Lafayette	110	5.6	34.7	46.4	13.28	4.87	4.95	61.59	1.08	14.23	11,200	...do	9
Do	Oxford	113	4.4	40.7	50.4	4.45	3.54	5.53	72.65	1.35	12.48	13,230	...do	9
Do	Adams	114	4.6	39.2	47.5	8.75	5.36	5.40	67.51	1.24	11.74	12,380	...do	9
Do	White Eyes	118	5.3	37.4	48.7	8.60	4.36	5.32	67.41	1.18	13.13	12,290	...do	9
Do	.....do	120	4.5	38.7	50.8	5.97	3.63	5.53	70.94	1.30	12.63	12,910	...do	9
Do	Keene	107	5.4	39.9	49.6	5.08	3.18	5.58	70.90	1.24	14.02	12,950	...do	9
Do	Crawford	117	4.7	39.2	44.8	11.29	5.60	5.23	64.78	1.12	11.98	11,870	...do	9
Do	Clark	106	5.3	39.1	49.5	6.15	3.72	5.50	69.59	1.12	13.92	12,750	...do	9
Tuscarawas	Salem	133	3.4	40.0	48.9	7.67	5.22	5.30	70.02	1.26	10.53	12,840	...do	9
Do	Clay	131	3.4	39.7	47.5	9.38	4.88	5.23	68.77	1.30	10.44	12,550	...do	9
Do	Jefferson	115	4.7	40.3	49.5	5.47	4.05	5.53	71.08	1.32	12.55	12,960	...do	9
Do	Mill	130	3.8	38.3	49.5	8.42	3.83	5.26	70.31	1.22	10.96	12,780	...do	9
Do	Dover	121	3.5	40.3	50.2	6.01	3.17	5.41	72.13	1.28	12.00	13,140	...do	9
Do	.....do	122	4.9	36.2	49.4	9.50	4.19	5.14	67.54	1.30	12.33	12,340	...do	9
Do	Goshen	123	3.5	41.6	47.2	7.69	4.56	5.45	70.26	1.22	10.82	12,880	...do	9
Do	Fairfield	138	7.1	38.3	50.0	4.56	2.62	5.64	71.29	1.23	14.66	12,950	...do	9
Do	.....do	127	4.7	39.2	49.9	6.22	3.28	5.48	70.80	1.28	12.94	12,780	...do	9
Do	Lawrence	125	4.7	39.5	46.7	9.06	4.70	5.30	67.59	1.24	12.11	12,390	...do	9
Do	Sandy	126	4.9	38.2	49.9	7.04	2.91	5.40	70.45	1.28	12.92	12,750	...do	9
Holmes	Walnut Creek	119	7.3	34.9	53.6	4.21	1.00	5.42	70.62	1.44	17.31	12,510	...do	9
Carroll	Orange	132	3.8	39.1	50.3	6.79	3.06	5.36	71.99	1.40	11.40	13,030	...do	9
Stark	Sandy	135	6.7	36.2	48.9	8.22	2.66	5.37	68.94	1.20	13.61	12,560	...do	9
Do	Nimishillen	139	5.6	38.5	45.8	10.08	4.13	5.29	66.92	1.19	12.39	12,360	...do	9
Columbiana	Liverpool	137	3.6	36.2	55.6	4.60	1.76	5.46	77.06	1.38	9.74	14,020	...do	9

Analyses of Ohio coals—Continued.

Lower Freeport coal (No. 6a).

County.	Township.	Mine or laboratory number.	Proximate.			Ultimate.						British thermal units.	Reference.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Organization.	Bull. No.
Jefferson	Springfield	10533	3.4	37.6	52.0	7.0	2.40						U. S. G. S.	531
Do.	do.	15388	3.7	37.4	51.2	7.7	3.07					13,220	do.	531
Do.	do.	15389	3.5	38.3	50.8	7.4	2.99					13,250	do.	531
Do.	do.	15390	3.3	38.9	50.3	7.5	3.23					13,250	do.	531
Do.	do.	15391	3.6	37.6	49.1	9.7	3.08					12,880	do.	531
Do.	do.	15392	3.5	38.6	49.6	8.3	2.40					13,220	do.	531
Do.	do.	15393	4.1	38.6	48.9	8.4	2.95					13,020	do.	531
Do.	do.	15440	3.4	38.0	52.4	6.2	2.20					13,530	do.	531
Do.	do.	15441	3.5	37.9	50.6	8.0	3.14					13,260	do.	531
Do.	do.	15443	3.6	37.0	50.7	8.74	3.70	5.19	71.30	1.39	9.68	13.000	do.	531
Do.	Steubenville	15675	3.8	35.9	53.4	6.85	1.90	5.24	74.20	1.45	10.36	13,350	do.	531
Do.	do.	15676	3.8	35.4	53.4	7.4	1.91					13,220	do.	531

Upper Freeport coal (No. 7).

Lawrence	Lawrence	147	7.2	32.2	49.9	10.67	2.33	5.03	65.03	1.25	15.69	11,800	Ohio	9
Do.	Aid	144	7.8	32.9	47.1	12.18	2.66	5.09	63.03	1.25	15.79	11,350	do.	9
Do.	do.	145	8.4	31.8	51.6	8.23	1.29	5.21	66.94	1.31	17.02	11,870	do.	9
Do.	do.	146	8.4	31.3	49.0	11.28	.93	5.10	65.20	1.28	16.21	11,530	do.	9
Do.	Symmes	140	7.1	33.7	50.3	8.91	1.31	5.33	67.09	1.28	16.08	12,090	do.	9
Do.	do.	141	8.8	31.7	50.8	8.71	.76	5.32	66.88	1.25	17.08	11,860	do.	9
Do.	do.	143	8.4	31.5	50.0	10.09	1.84	5.18	64.90	1.27	16.72	11,700	do.	6
Gallia	Walnut	142	7.6	32.9	47.1	12.39	1.81	5.19	63.48	1.28	15.85	11,470	Ohio	9
Muskingum	Harrison	148	4.9	42.3	45.0	7.78	4.36	5.53	67.74	1.17	13.42	12,500	do.	9
Do.	Brush Creek	149	4.7	43.5	44.2	7.56	5.00	5.55	68.27	1.32	12.30	12,680	do.	9
Do.	Wayne	150	5.1	35.5	46.8	12.60	3.84	5.11	64.81	1.25	12.39	11,800	do.	9
Coshocton	Clark	151	6.4	37.9	52.5	3.19	2.01	5.67	72.72	1.25	15.16	13,190	do.	9
Guernsey	Center	2090	6.3	35.8	50.6	7.3	3.55					12,700	U. S. G. S.	290
Do.	do.	2091	5.8	36.9	50.7	6.6	2.62						do.	290
Do.	Valley	20245	6.9	34.1	53.3	5.7	.84					12,790	do.	621
Do.	do.	20246	6.2	36.2	52.3	5.3	.86					13,000	do.	621
Do.	Richland	20261	5.4	35.8	50.8	8.0	1.64					12,780	do.	621
Do.	do.	20262	6.4	33.7	52.1	7.8	2.16					12,630	do.	621
Do.	Center	20264	6.1	35.2	51.8	6.9	1.62					12,740	do.	621
Do.	do.	20265	6.0	35.7	50.4	7.9	2.15					12,660	do.	621
Noble	Noble	17213	4.9	37.8	48.9	8.4	2.95					12,730	Mines	85
Do.	do.	17214	5.1	37.2	49.6	8.1	2.99					12,700	do.	85

Pittsburgh coal (No. 8).

Gallia	Ohio	25	5.8	36.7	47.4	10.06	4.34	5.16	64.94	1.10	14.40	11,790	Ohio	9
Do.	Harrison	27	7.0	36.1	47.9	9.03	5.21	5.24	64.91	1.01	14.60	11,850	do.	9
Do.	do.	28	7.8	34.1	48.3	9.76	3.89	5.18	64.59	1.09	15.49	11,780	do.	9
Do.	Green	26	6.7	34.4	45.9	13.03	4.37	5.11	62.30	1.14	14.05	11,440	do.	9
Athens	Ames	23	5.8	37.4	48.8	8.00	4.19	5.14	67.55	.95	14.17	12,300	do.	9
Do.	Berne	24	6.6	35.1	48.1	10.20	3.41	5.13	66.61	.93	13.72	11,890	do.	9
Do.	do.	24	4.5	38.2	45.8	11.49	4.88	5.10	65.92	.99	11.62	11,950	do.	9
Morgan	Homer	22	6.9	40.5	44.4	8.19	4.22	5.32	67.39	.90	13.98	12 100	do.	9
Guernsey	Millwood	20178	4.4	41.1	45.8	8.74	4.85	5.37	69.30	1.26	10.48	12,710	U. S. G. S.	621
Belmont	Washington	9	2.8	37.9	49.9	9.42	5.09	5.25	69.76	1.09	9.39	12,990	Ohio	9
Do.	Somerset	11	4.1	37.1	48.2	10.61	4.95	4.89	68.77	1.10	9.68	12,480	do.	9
Do.	do.	20187	4.1	42.7	43.9	9.3	4.46					12,730	U. S. G. S.	621
Do.	do.	20188	3.7	43.3	44.4	8.6	4.45					12,950	do.	621
Do.	do.	20230	3.7	41.0	45.8	9.5	4.57					12,760	do.	621
Do.	Mead	8	2.9	37.9	51.2	8.00	4.31	5.11	72.95	1.04	8.59	13,210	Ohio	9
Do.	Pultney	2095	4.0	38.8	49.1	8.1	3.49					13 100	U. S. G. S.	290
Do.	do.	3985	4.1	39.2	48.7	8.0	4.12					13,090	do.	332
Do.	do.	3988	3.1	40.8	50.1	6.0	3.42					13,600	do.	332
Do.	do.	3	3.5	38.6	51.0	6.86	3.76	5.45	72.08	1.17	10.70	13,190	Ohio	9
Do.	do.	4	3.8	37.2	50.1	8.95	4.27	5.23	70.57	1.20	9.78	12,790	do.	9
Do.	Smith	7	3.2	36.8	52.7	7.26	4.28	5.14	71.49	1.06	10.77	13,140	do.	9
Do.	Warren	10	4.5	37.5	47.0	11.01	4.67	5.17	67.64	1.08	10.43	12,380	do.	9
Do.	Union	6	3.8	38.0	47.4	10.84	4.76	5.09	67.41	1.11	10.79	12,360	do.	9
Do.	do.	5	4.4	36.0	48.8	10.76	4.45	4.85	68.24	1.10	10.60	12,430	do.	9
Do.	Pease	1	3.4	36.8	51.9	7.86	2.97	5.21	71.45	1.24	11.27	12,990	do.	9
Do.	Colerain	2	3.8	36.4	50.8	9.00	4.16	5.14	70.41	1.09	10.20	12,860	do.	9
Do.	Wheeling	6a	4.2	33.5	51.9	10.35	3.95	5.19	68.17	1.09	11.25	12,430	do.	9
Do.	Flushing	2a	4.2	36.4	50.2	9.21	4.17	5.14	68.75	1.09	11.64	12,610	do.	9
Do.	do.	3986	4.1	39.2	48.7	8.0	4.12					13,090	U. S. G. S.	332
Jefferson	Mount Pleasant	12	3.1	37.9	49.5	9.52	3.83	5.22	69.56	1.10	10.77	12,880	Ohio	9
Do.	Warren	15	3.1	37.9	50.8	8.22	4.02	5.38	71.03	1.26	10.09	13,020	do.	9
Do.	do.	1944	4.7	35.6	53.7	6.0	1.54					13,330	U. S. G. S.	290
Do.	do.	15a	4.6	32.4	51.0	9.00	1.55	5.06	71.18	1.32	11.89	12,790	Ohio	9
Do.	Wells	16	4.9	33.1	51.5	10.46	4.09	5.03	68.01	1.12	11.29	12,520	do.	9
Do.	do.	15563	3.8	38.8	50.0	7.4	3.84					13,080	U. S. G. S.	531
Do.	do.	15564	4.3	37.4	50.3	8.0	3.72					12,960	do.	531
Do.	Smithfield	13	5.0	34.5	54.1	6.45	1.75	5.37	72.43	1.33	12.67	13,100	Ohio	9
Do.	do.	19	4.2	37.0	50.6	8.22	2.83	5.36	71.20	1.26	11.13	12,890	do.	9
Do.	do.	14	4.3	35.3	52.5	7.88	3.01	5.18	71.34	1.20	11.39	12,860	do.	9
Do.	do.	1910	4.1	38.5	49.7	7.7	3.67					13,150	U. S. G. S.	290
Do.	do.	15486	4.8	35.9	54.0	5.31	.98	5.35	74.13	1.46	12.77	13,350	do.	531
Do.	do.	15487	4.5	36.4	51.1	8.00	3.33					12,880	do.	531
Do.	do.	15488	4.3	36.6	52.2	6.9	2.57					13,150	do.	531
Do.	do.	15489	4.9	36.6	51.2	7.25	2.60	5.36	71.91	1.38	11.50	12,990	do.	531
Do.	do.	15490	5.4	35.8	53.3	5.5	.77					13,180	do.	531

Analyses of Ohio coals—Continued.

Pittsburgh coal (No. 8)—Continued.

County.	Township.	Mine or laboratory number.	Proximate.					Ultimate.				British thermal units.	Reference.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Organization.	Bull. No.
Jefferson	Smithfield	15491	5.5	35.7	51.2	4.6	.84					13,320	...do	531
Do	Wayne	17	5.0	35.9	51.1	7.95	2.61	5.32	70.68	1.25	12.19	12,870	Ohio	9
Harrison	Short Creek	18	6.5	35.5	51.3	6.74	2.19	5.70	70.19	1.22	13.66	12,710	...do	9
Do	Athens	21	6.0	34.3	53.7	5.97	1.35	5.44	72.22	1.31	13.71	12,960	...do	9
Do	Cadiz	20	3.8	36.7	48.6	10.88	4.38	5.09	67.70	1.27	10.68	12,360	...do	9
Do	Green	15444	5.0	36.2	52.8	6.0	1.74					13,190	U.S.G.S.	531
Do	...do	15445	4.3	37.1	49.1	9.5	3.82					12,730	...do	531

Pomeroy coal (No. 8a).

County.	Township.	Mine or laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	British thermal units.	Organization.	Bull. No.
Gallia	Cheshire	34	8.2	34.2	46.1	11.46	2.18	5.48	62.95	1.02	16.91	11,500	Ohio	9
Meigs	Sutton	33	4.8	36.3	46.4	12.52	2.94	5.32	65.29	1.17	12.76	11,920	...do	9
Do	Salisbury	29	7.3	34.6	49.4	8.69	2.05	5.53	66.71	1.06	15.96	12,110	...do	9
Do	...do	30	7.2	32.8	50.7	9.29	1.32	5.39	66.47	1.10	16.43	12,000	...do	9
Do	...do	31	5.5	38.2	45.7	10.58	4.17	5.40	65.55	.95	13.35	11,090	...do	9
Do	Rutland	32	7.6	33.4	48.1	10.93	1.83	5.20	65.29	1.03	15.72	11,720	...do	9

Meigs Creek coal (No. 9).

County.	Township.	Mine or laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	British thermal units.	Organization.	Bull. No.
Washington	Adams	53	2.9	37.5	46.7	12.89	5.55	5.05	65.88	.92	9.71	12,250	Ohio	9
Do	Aurelius	52	3.4	37.9	49.1	9.58	5.03	5.31	68.33	.90	10.85	12,750	...do	9
Noble	Elk	44	3.1	38.4	46.2	12.33	6.00	5.11	66.18	.86	9.52	12,360	...do	9
Do	Enoch	45	2.9	37.2	49.7	10.16	4.27	5.22	68.53	1.04	10.78	12,690	...do	9
Do	Stock	43	2.6	38.4	47.6	11.41	5.79	5.11	67.50	.92	9.27	12,510	...do	9
Do	Marion	42	3.1	37.4	46.7	12.85	5.60	5.09	65.61	.92	9.93	12,130	...do	9
Do	Brookfield	47	3.6	37.4	45.8	13.23	6.21	5.12	64.44	.88	10.12	11,960	...do	9
Do	...do	46	4.8	37.3	48.1	9.82	5.59	5.26	66.01	.97	12.35	12,300	...do	9
Do	Seneca	20235	4.5	39.6	45.6	10.32	4.12	5.27	68.00	1.17	11.12	12,320	U.S.G.S.	621
Do	...do	20240	3.6	41.5	44.4	10.53	4.87	5.25	68.15	1.11	10.09	12,510	...do	621
Do	Beaver	20185	4.2	38.4	44.8	12.62	3.61	5.22	66.87	1.20	10.48	12,130	...do	621
Morgan	Meigsville	50	5.1	36.1	47.1	11.74	4.89	5.06	64.77	.87	12.67	11,930	Ohio	9
Do	Bristol	48	5.0	37.8	46.8	10.37	4.30	5.14	67.04	.89	12.26	12,110	...do	9
Do	Manchester	49	4.1	37.6	47.6	10.66	5.07	5.10	66.19	.87	12.11	12,200	...do	9
Belmont	Washington	20237	3.5	37.2	41.5	17.8	4.05					11,510	U.S.G.S.	621
Do	Warren	20176	4.3	39.0	45.5	11.21	3.65	5.31	68.17	1.20	10.46	12,400	...do	621
Do	...do	37	4.5	35.3	47.1	13.07	3.27	4.99	65.83	1.13	11.71	12,000	Ohio	9
Do	Goshen	40	3.4	35.7	46.0	14.94	4.39	4.86	64.77	1.08	9.96	11,840	...do	9
Do	Smith	41	3.5	34.8	49.9	11.84	3.67	5.02	67.36	1.05	11.06	12,390	...do	9
Do	Union	39	4.2	35.1	51.1	9.60	3.11	4.97	69.90	1.09	11.33	12,600	...do	9
Do	...do	38	4.3	32.5	51.5	11.68	1.94	5.09	68.32	1.11	11.86	12,310	...do	9
Do	Wheeling	36a	7.5	31.8	49.5	11.24	2.11	5.14	66.41	1.11	13.99	11,860	...do	9
Do	Flushing	36	5.0	33.3	48.9	12.82	2.41	4.95	66.31	1.19	12.32	11,970	...do	9
Harrison	Athens	35	5.3	33.1	51.3	10.29	2.20	5.21	68.67	1.25	12.38	12,390	...do	9

Uniontown coal.

County.	Township.	Mine or laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	British thermal units.	Organization.	Bull. No.
Monroe	Center	20259	4.9	35.9	43.9	15.32	3.96	4.87	63.59	1.19	11.07	11,540	U.S.G.S.	621
Belmont	Wayne	20775	4.7	34.2	45.8	15.34	2.85	4.95	63.71	1.33	11.82	11,660	...do	621

Waynesburg coal.

County.	Township.	Mine or laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	British thermal units.	Organization.	Bull. No.
Belmont	Somerset	20234	4.4	37.1	43.1	15.4	2.90					11,660	U.S.G.S.	621
Do	...do	20241	4.5	36.6	44.2	14.75	3.02	5.10	65.32	1.16	10.65	11,800	...do	621
Do	Washington	20236	4.6	36.8	44.2	14.4	2.59					11,830	...do	621
Do	Goshen	20174	4.3	35.3	44.2	16.22	3.53	4.98	64.10	1.20	9.97	11,610	...do	621

Washington coal.

County.	Township.	Mine or laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	British thermal units.	Organization.	Bull. No.
Belmont	Washington	20238	4.1	33.7	41.2	21.00	2.86	4.76	59.93	1.09	10.36	10,820	U.S.G.S.	621

USES OF OHIO COALS.

RANGE OF THE COALS.

The coals of Ohio have nothing like the range in composition possessed by the coals of Pennsylvania and West Virginia. In Pennsylvania the varieties extend from anthracite to gas coals like the Pittsburgh, and in West Virginia from semibituminous coals like the Pocahontas and New River, with their low content of volatile matter and high percentage of fixed carbon, to the Pittsburgh coal, whose qualities are similar to those of the same coal in Pennsylvania. The Ohio coals, on the other hand, are all bituminous.

COKE.

In former years several Ohio coals have been coked, but not a pound of coke is now made from them in the State, except possibly as a by-product. At Leetonia, Columbiana County, the Lower Kittanning coal was long coked for local use in iron furnaces, but the ovens there have not been fired for years. The coal bed was thin and therefore expensive to work, and the coke, although good, did not equal the standard Connellsville coke. The Middle Kittanning coal was formerly coked in a small way at Hammondsville, Jefferson County, but according to Orton it is too high in ash and sulphur. Moreover, the coal in that locality does not exceed 30 inches in thickness.

The Freeport coals have both been the basis of a small coking industry. The Lower Freeport coal was used for many years for this purpose at Steubenville and yielded a fair coke, but the industry fell into decay, and Pennsylvania coke has taken the place of the product. Slack coal from the Upper Freeport bed was formerly coked at Salineville, but the product was of poor quality. The same bed was once coked at Happy Hollow in western Athens County, but the coal was dirty and high in sulphur, and the coke could not be used where a first-class product was required.

The Pittsburgh coal has been coked on a large scale in Ohio, but the product is not equal to that made in the vicinity of Connellsville, Pa., or along New River, W. Va. The coal is too high in sulphur, but this difficulty might be overcome by washing. A dozen ovens were once in operation in the valley of Wheeling Creek a few miles west of Bridgeport. Slack coal only seems to have been used, but the market for the product was small. Near Utley, in northern Athens County, coke was made from the Pittsburgh coal. About 125 ovens were built, but probably not more than 50 of them were used at any one time, and the last were abandoned nearly 20 years ago. Lathrop, which is a few miles north of Utley, has 50 ovens, but except possibly for a short period in 1907 or 1908 they have not been in use for many years. Slack coal was used at Utley, the lump being thought too expensive. The coke is reported to have found a ready market in several large western cities, but the coal is too high in sulphur to make first-class coke.

RAW COAL FOR FURNACE USE.

The Sharon coal in the natural state is still used at Jackson for making pig iron. The Wellston coal, according to Orton, was formerly used for the same purpose, but it appears to be too high in sulphur and has not been used in iron making for a long time. The Sharon coal in northern Ohio, and especially that of the Mahoning Valley, was once used on a large scale in the blast furnaces of that locality. It was excellent for the purpose, but the bed was thin and the coal, good as it was, did not compare with Connellsville coke for iron making. The Middle Kittanning coal in the Hocking Valley had about 35 years ago a large market in the natural state for use in local blast furnaces. Iron ore was obtained from the same territory, and for a time the industry flourished, but the ores could not compete with those from Michigan, nor was the coal as fuel equal to coke from Pennsylvania, and the industry was short lived.

DOMESTIC USE.

Every coal in Ohio is used for domestic purposes and choice is largely a question of market conditions. The Sharon and Quakertown coals are most prized for this purpose of all the coals of Ohio, and they rank among the best in this country. The Middle Kittanning coal has a large sale for this use. It is among the strongest of the Ohio coals and hence has relatively little slack. It generates a large amount of heat and carries only a moderate percentage of sulphur, but unless the miners are careful shale or clay may be loaded with coal, which thus increases the ash and possibly forms clinker. The Pittsburgh coal also has a large market for domestic use. It is easily ignited, makes a good heat, and is moderate in ash and sulphur, but its tendency to fuse and cut off the draft is objectionable.

GAS MAKING.

Before the advent of natural gas various Ohio coals were used for gas making. Probably the coal from the Middle Kittanning bed had the most extensive market for this purpose, but this may have been due to its having been worked in a larger way than other Ohio coals. The coal is high in volatile matter, but the residue makes a very poor coke, which of course operates against the bed. Probably the Pittsburgh coal is the best of the large deposits of Ohio for making gas. It is high in volatile matter and makes better coke than any other Ohio coal of a similar quantity. When the natural gas supply in Ohio has failed, as it will in the near future, the better grades of Pittsburgh coal will, in all probability, find a large market for gas making.

STEAM RAISING.

Every coal in Ohio that has workable thickness under existing conditions is used for steam production, and whether one coal or another is used depends largely on the price. However, large purchasers are now taking into consideration the quality of the coal, and especially its heating value, sulphur, and ash. The following figures, taken almost wholly from the records of the Ohio Geological Survey, furnish data on these points:

Quality of Ohio coals.

Coal bed.	Ash.	Sulphur.	B. t. u.
Clarion (17 samples)	10. 8	4. 33	11, 950
Lower Kittanning (9 samples)	7. 9	3. 26	12, 580
Middle Kittanning (65 samples)	7. 4	3. 30	12, 560
Upper Freeport (17 samples)	9. 0	2. 54	12, 870
Pittsburgh (32 samples)	9. 1	3. 81	12, 560
Pomeroy (6 samples)	10. 6	2. 42	11, 870
Meigs Creek (19 samples)	11. 6	4. 28	12, 240

However, the composition of Ohio coals varies considerably from place to place and in places from mine to mine. Thus the Clarion coal, which is important in only four counties in the southern part of the State, ranges in heat value (rejecting one sample taken from a weathered surface) from 11,130 to 12,530 B. t. u., in sulphur from 2.81 to 6.14, and in ash from 6.2 to 15.3 per cent. This coal is high in both sulphur and ash, and its heat value is not so high as that of most Ohio coals. Nevertheless, it finds a market for steam generation, and this market will doubtless improve as the better coals are worked out. The Lower Kittanning coal is more regular. Its quality is best in the northeastern part of the State, as the table of analyses shows, but unfortunately its quantity is not large.

The great Middle Kittanning bed, noted for its regularity, shows but slight changes from Columbiana County southwestward to Ohio River. Its quality is shown in the following table:

Quality of the Middle Kittanning coal bed from Columbiana County southwestward to Ohio River.

County or field.	Ash.	Sulphur.	B. t. u.
Columbiana, Stark, Carroll, and Holmes (5 samples)	6. 8	2. 51	12, 900
Tuscarawas (16 samples)	7. 3	3. 85	12, 800
Coshocton (11 samples)	6. 8	3. 82	12, 550
Muskingum and northern Perry (10 samples)	8. 4	3. 72	12, 310
Hocking Valley (8 samples)	6. 2	1. 22	12, 500
Hocking Valley to Ohio River (8 samples)	8. 2	3. 21	12, 430

According to the figures given above, this coal has the highest heat value in the northeastern part of the State and decreases to the southwest all the way to Ohio River, except in the Hocking Valley field, where this value is a little higher than in the adjacent areas on the north and south. The figures for the Hocking Valley field also show the lowest percentage of ash and a sulphur percentage less than half that of the next lowest.

The Middle Kittanning coal has long had an extensive market for steam purposes. It is open burning and therefore does not cut off the draft. However, unless the shale partings and pyrite are carefully sorted out, clinkers form, which reduce the draft and may ruin the grate bars. The coal is tough and strong and forms less slack than most Ohio coals. Its heat value is good, and it is moderate in both ash and sulphur.

The Upper Freeport coal shows a greater range in quality than the Middle Kittanning, as indicated below:

Quality of the Upper Freeport coal.

Counties.	Ash.	Sulphur.	B. t. u.
Guernsey and Noble (5 samples)	7. 8	3. 01	12, 720
Muskingum and Coshocton (4 samples)	7. 8	3. 80	12, 540
Lawrence and Gallia (8 samples	10. 3	1. 62	11, 710

The Upper Freeport coal is more distinctly a steam coal than any other in Ohio. In fact, steam making is its one great use. It does not make a good coke, is too high in sulphur for furnace use, and forms too much slack for domestic purposes. The coal from the Cambridge field is one of the best, viewed from the standpoint of heating value, and the sulphur and ash are not excessive.

As stated on the preceding page the Pittsburgh coal forms three distinct fields, and the average quality of the coal in each field is shown below:

Quality of the Pittsburgh coal.

Field.	Ash.	Sulphur.	B. t. u.
Belmont (24 samples)..........	8. 8	3. 71	12, 780
Federal Creek (4 samples).....	9. 5	4. 18	12, 060
Swan Creek (4 samples).......	10. 5	4. 45	11, 720

These analyses show that this coal deteriorates toward the southwest. The Pittsburgh coal has a large market for steam making for both locomotives and stationary boilers. It is excellent for this purpose, though its tendency to fuse in burning may reduce the draft.

The Pomeroy coal is high in ash, averaging over 10 per cent, but it is lower in sulphur than the Pittsburgh coal, and has fair heating power. It also is well adapted to the generation of steam.

The Meigs Creek coal, the highest stratigraphically of the important beds in Ohio, ranks well in heating value, but it is high in both sulphur and ash and therefore is not the equal of most other Ohio coals for steam production.

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ORIGINAL COAL CONTENT OF THE FIELDS.

By Frank R. Clark.

INTRODUCTION.

The coal tonnage of any field is hard to ascertain and may be very differently estimated, even by geologists or engineers using the same set of facts. The estimate herein made is based not on original field work by the author but on a careful study of the facts contained in the reports of the Ohio Geological Survey. The writer's estimate, 87,638,000,000 short tons, is so much higher than any heretofore published that it seems to require an explanation and a careful statement as to its basis and of the manner of its computation.

Three factors have contributed more or less to make the writer's estimate larger than that of others who have essayed to make an inventory of the available coal of Ohio. These factors are (1) the inclusion in the present estimate of the tonnage of coal contained in beds below drainage level, (2) the fixing of a minimum thickness considerably below that which is now considered to be the limit of workability, and (3) the estimation of the original tonnage before mining began rather than that which is still available in the ground. The estimates made by the United States Geological Survey are based on the principle that they should include all coal beds that ever will be mined, regardless of present mining conditions; consequently beds below drainage level, unless they lie at a depth of 5,000 or 6,000 feet, should be considered just as much as those exposed in outcrop, and thin beds should be included as well as thick beds, for sooner or later all will be required to help satisfy the world's demand for fuel. The fixing of a minimum thickness below that which is to-day considered the limit of workability is of course open to question, but the minimum limit fixed, 14 inches, was adopted for all high-rank coal after consideration of thin coal beds mined at present both in this country and abroad. Possibly beds even thinner than 14 inches may be worked when all the thick beds have been exhausted.

The estimate here given was made in 1912 in connection with a computation of the coal resources of the United States and was first published in the "Coal resources of the world" as a part of the proceedings of the Twelfth International Geological Congress at Ottawa, Canada, in 1913. The figures given in that report, 93,967,916,000 short tons, have been somewhat modified on account of new information regarding the absence of coal where it was formerly supposed to be present [1] and by giving tonnage figures in round numbers to the nearest million.

DATA ON WHICH ESTIMATES ARE BASED.

The data used in making the estimate were taken from the Geological Survey of Ohio reports for 1869 and 1870 (two volumes), for 1873 to 1893 (vols. 1 to 7, inclusive), and from Coal Bulletin 9, 1908, Oil and Gas Bulletin 1, 1903, and Bulletin 20 (4th series), 1916. In addition to the data in these reports some information regarding the counties adjoining Ohio on the east was obtained from the reports published by the Geological Survey of Pennsylvania and by that of West Virginia.

Although the Ohio reports are voluminous, much of the material contained in them, especially in the earlier ones, is indefinite, because it does not indicate the exact locations of all the measured coal sections and because the maps do not show the outcrops of all the coal beds. At the time these estimates were made (1912) the only maps available were those (Nos. 1 to 10, inclusive) accompanying volume 7 (Reports for 1873–1893) and two others in Bulletin 9. These maps show the position of the base of the coal measures and the outcrops of the Middle Kittanning, Upper Freeport, Pittsburgh, Pomeroy, and Meigs Creek coal beds. They represent the probable area of the coal beds above drainage level, but they do not show how far below drainage any of the beds may extend.

All data obtained from the various sources named regarding the thickness of the coal beds (every recorded section being used), the regular or irregular habit of any particular bed, and the probable area underlain by each bed were properly tabulated under beds, townships, and counties.

METHODS OF COMPUTATION.

The nature of the data makes it necessary to divide the work of computation into two parts—(1) estimates of beds whose outcrops have been mapped and (2) estimates of beds whose outcrops have not been mapped and whose areas had to be estimated from the facts recorded in the text. As the Lower Kittanning lies only a short distance below the Middle Kittanning, and the Lower Freeport only a short distance below the Upper Freeport, the outcrops of each group were assumed to be essentially parallel.

All the detailed sections of a particular coal bed were first averaged by townships. Then all these township averages and the sections in adjoining township of other counties were again averaged to obtain the average thickness for the county. The probable area underlain by the coal bed was carefully measured with a planimeter from the maps showing the coal outcrops. The part of the total area lying above drainage level was taken directly from the coal maps, and the part lying below drainage level was estimated on the assumption (in the absence of definite measurements) that a coal bed which is persistent along its outcrop and reasonably constant in thickness will have approximately the same average thickness below drainage level that it has above that level. In the absence of positive evidence that coal is not present it was also assumed that a bed may extend below drainage level toward the center of the main coal basin at right angles to the strike of the beds for a distance equal to that through which it is known to extend above drainage level. Such an assumption, though altogether arbitrary, is at least reasonable and conservative. Concerning it as well as the other assumptions differences of opinion may exist, because they can not be based on hard and fast rules. Obviously, however, there is no good reason for assuming that coal beds lying in relatively undisturbed areas are absent below drainage level simply because their presence has not been proved by mining or drilling. The making of an estimate where the bed lies above drainage level is also attended with difficulties, for here one must also assume that the coal is present or absent, and if the former that it continues at about the average thickness in areas concerning which little or no information is available. The determination of the average thickness of a coal bed as well as its areal extent was greatly facilitated at many points by records of deep borings published in the State reports.

The coal beds which contribute more or less to the total coal of Ohio but which are not shown in outcrop on any of the maps published before 1912 are the Sharon, Wellston (Quakertown), Lower Mercer, Upper Mercer, Tionesta, Brookville, Clarion, Wilgus, Brush Creek (coals 7a and 7b?), Jeffers, coal No. 10 (wanting in Pennsylvania), Waynesburg (coal No. 11), and Brownsville (coal No. 12). The determination of the probable areas underlain by each of these coal beds was very difficult and unsatisfactory. The areas were obtained with the aid of maps showing the outcrop of the base of the coal measures, the outcrops of the more important coal beds, the location of coal sections, the records of deep borings, and references in the text of the State reports.

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[1] This zone of barren territory or "fault" in the Hocking Valley coal field is shown in Pl. III of this report.

The average thickness of each of the coal beds mentioned above in any unit of area (such as the county, township, or less) was obtained by averaging all the sections of coal affecting any one unit area in the same manner as that described for the more important beds.

With the area and thickness of the coal bed determined the next step was to determine the weight. Coal varies somewhat in weight, but the average of most bituminous coals with an ash content of not more than 8 per cent has a specific gravity of about 1.3. This means that an acre-foot of coal will weigh about 1,800 short tons and that a square-mile-foot will weigh about 1,152,000 short tons. These figures multiplied by the average thickness of the bed expressed in feet gives the tonnage of the coal bed under an acre or a square mile of ground.

THE ESTIMATES.

The following table gives the tonnage by beds and counties. The first column gives the name of the coal bed; the second, the calculated average thickness in feet and inches; the third, the area in square miles considered to contain the coal bed with the average thickness shown in column 2; the fourth, the tons per square mile corresponding to each thickness given in column 2; the fifth, the product in round numbers to the nearest million of the figures in columns 3 and 4; and the sixth, the sum of all figures in column 5. This table contains the tonnage of 20 coal beds which contribute more or less to the fuel supply of the State, and one or more of the beds is considered to be present in 31 counties in eastern Ohio.

Estimated coal tonnage by beds and counties.

Athens County.

Name of coal bed.	Average thickness.		Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
	Ft.	*in.*				
Pomeroy	2	5	25	2,784,000	70,000,000	6,218,000,000
Pittsburgh	4	2	115	4,800,000	552,000,000	
Upper Freeport	4	0	330	4,608,000	1,521,000,000	
Lower Freeport	2	10	130	3,264,000	424,000,000	
Middle Kittanning	5	5	430	6,240,000	2,683,000,000	
Lower Kittanning	2	0	420	2,304,000	968,000,000	
Belmont County.						
Waynesburg and Brownsville	1	8	60	1,920,000	115,000,000	7,984,000,000
Coal No. 10	3	4	130	3,840,000	499,000,000	
Meigs Creek	3	9	385	4,320,000	1,663,000,000	
Pittsburgh	4	11	475	5,664,000	2,690,000,000	
Upper Freeport	3	8	515	4,224,000	2,175,000,000	
Lower Freeport	3	3	225	3,744,000	842,000,000	

Estimated coal tonnage by beds and counties—Continued.

Name of coal bed.	Average thickness.		Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
	Ft.	*in.*				
Carroll County.						
Brush Creek ("Harlem" coal No. 7b)	1	5	15	1,632,000	24,000,000	5,193,000,000
Upper Freeport	3	8	260	4,224,000	1,098,000,000	
Lower Freeport	3	1	250	3,552,000	888,000,000	
Middle Kittanning	4	0	370	4,608,000	1,705,000,000	
Lower Kittanning	2	9	370	3,168,000	1,172,000,000	
Brookville	2	5	110	2,784,000	306,000,000	
Columbiana County.						
Brush Creek	2	11	200	3,360,000	672,000,000	5,871,000,000
Upper Freeport	4	4	245	4,992,000	1,223,000,000	
Lower Freeport	2	3	175	2,592,000	454,000,000	
Middle Kittanning	2	6	430	2,880,000	1,238,000,000	
Lower Kittanning	2	3	500	2,592,000	1,296,000,000	
Clarion	3	3	120	3,744,000	449,000,000	
Lower Mercer	2	4	175	2,688,000	470,000,000	
Sharon	2	0	30	2,304,000	69,000,000	
Coshocton County.						
Upper Freeport	3	0	5	3,456,000	17,000,000	2,130,000,000
Middle Kittanning	3	4	195	3,840,000	749,000,000	
Lower Kittanning	3	2	195	3,648,000	711,000,000	
Brookville	2	3	190	2,592,000	492,000,000	
Upper Mercer	6	8	2	7,680,000	15,000,000	
	1	10	20	2,112,000	42,000,000	
Lower Mercer	2	0	35	2,304,000	81,000,000	
Sharon	2	0	10	2,304,000	23,000,000	
Gallia County.						
Pomeroy	2	5	90	2,784,000	251,000,000	3,791,000,000
Pittsburgh	3	5	40	3,956,000	158,000,000	
Jeffers (local name for Pittsburgh)	3	7	90	4,128,000	372,000,000	
Upper Freeport	4	3	45	4,896,000	220,000,000	
Lower Freeport	2	1	30	2,400,000	72,000,000	
Middle Kittanning	3	1	425	3,552,000	1,600,000,000	
Lower Kittanning	2	4	300	2,688,000	806,000,000	
Clarion	2	1	130	2,400,000	312,000,000	
Guernsey County.						
Pittsburgh	3	8	20	4,224,000	84,000,000	4,687,000,000
Brush Creek	2	0	300	2,304,000	691,000,000	
Upper Freeport	2	5	370	2,784,000	1,030,000,000	
	5	10	40	6,720,000	269,000,000	
Lower Freeport	1	11	30	2,208,000	66,000,000	
Middle Kittanning	2	11	360	3,360,000	1,210,000,000	
Lower Kittanning	2	9	360	3,168,000	1,140,000,000	
Brookville	2	5	35	2,784,000	97,000,000	
Lower Mercer	2	2	40	2,496,000	100,000,000	

Estimated coal tonnage by beds and counties—Continued.

Harrison County.

Name of coal bed.	Average thickness.		Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
	Ft.	*in.*				
Coal No. 10	1	10	30	2,112,000	63,000,000	5,615,000,000
Meigs Creek	4	2	30	4,800,000	144,000,000	
Pittsburgh	4	11	110	5,664,000	623,000,000	
Brush Creek	2	5	70	2,784,000	195,000,000	
Upper Freeport	3	4	295	3,840,000	1,133,000,000	
Lower Freeport	3	0	265	3,456,000	916,000,000	
Middle Kittanning	4	0	315	4,608,000	1,452,000,000	
Lower Kittanning	3	0	315	3,456,000	1,089,000,000	

Hocking County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Upper Freeport	3	6	10	4,032,000	40,000,000	813,000,000
Lower Freeport	3	4	10	3,840,000	38,000,000	
Middle Kittanning	6	3	40	7,200,000	288,000,000	
Lower Kittanning	2	3	45	2,592,000	117,000,000	
Clarion	2	6	5	2,880,000	14,000,000	
Brookville	2	0	10	2,304,000	23,000,000	
Tionesta	2	9	50	3,168,000	158,000,000	
Upper Mercer	1	4	20	1,536,000	31,000,000	
Lower Mercer	2	0	45	2,304,000	104,000,000	

Holmes County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Middle Kittanning	3	4	30	3,840,000	115,000,000	940,000,000
Lower Kittanning	2	11	30	3,360,000	101,000,000	
Brookville	2	0	20	2,304,000	46,000,000	
Tionesta	2	6	5	2,880,000	14,000,000	
Upper Mercer	3	2	40	3,648,000	146,000,000	
Lower Mercer	3	0	80	3,456,000	276,000,000	
Quakertown	2	0	55	2,304,000	127,000,000	
Sharon	2	0	50	2,304,000	115,000,000	

Jackson County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Upper Freeport	5	2	1	5,952,000	6,000,000	1,123,000,000
Middle Kittanning	2	0	40	2,304,000	92,000,000	
Lower Kittanning	2	11	50	3,360,000	168,000,000	
Clarion	3	7	80	4,128,000	330,000,000	
Brookville	2	0	5	2,304,000	12,000,000	
Tionesta	2	0	5	2,304,000	12,000,000	
Upper Mercer	1	4	10	1,536,000	15,000,000	
Quakertown	2	8	120	3,072,000	369,000,000	
Sharon	2	7	40	2,976,000	119,000,000	

Jefferson County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Coal No. 10	1	6	20	1,728,000	35,000,000	5,986,000,000
Pittsburgh	4	11	110	5,664,000	623,000,000	
Brush Creek	3	2	155	3,648,000	565,000,000	
Upper Freeport	3	5	130	3,936,000	512,000,000	
Lower Freeport	4	0	380	4,608,000	1,751,000,000	
Middle Kittanning	2	8	395	3,072,000	1,213,000,000	
Lower Kittanning	2	6	395	2,880,000	1,138,000,000	
Lower Mercer	2	7	50	2,976,000	149,000,000	

Estimated coal tonnage by beds and counties—Continued

Name of coal bed.	Average thickness.		Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers)
	Ft.	*in.*				
Lawrence County.						
Pomeroy	2	5	40	2,784,000	111,000,000	2,393,000,000
Jeffers (local name for Pittsburgh)	1	3	20	1,440,000	29,000,000	
Wilgus	2	0	75	2,034,000	173,000,000	
Upper Freeport	3	3	135	3,744,000	505,000,000	
Lower Freeport	2	9	40	3,168,000	127,000,000	
Middle Kittanning	2	8	100	3,072,000	307,000,000	
Lower Kittanning	2	7	200	2,976,000	595,000,000	
Clarion	3	1	50	3,552,000	178,000,000	
Tionesta	1	8	60	1,920,000	115,000,000	
Upper Mercer	1	10	120	2,112,000	253,000,000	
Licking County.						
Lower Mercer	2	4	5	2,688,000	13,000,000	48,000,000
Sharon	2	0	15	2,304,000	35,000,000	
Mahoning County.						
Middle Kittanning	2	6	70	2,880,000	202,000,000	1,479,000,000
Lower Kittanning	2	4	70	2,688,000	188,000,000	
Clarion	3	4	50	3,840,000	192,000,000	
Upper Mercer	2	4	175	2,688,000	470,000,000	
Lower Mercer	2	7	50	2,976,000	149,000,000	
Sharon	2	5	100	2,784,000	278,000,000	
Medina County.						
Sharon	3	2	20	3,648,000	73,000,000	73,000,000
Meigs County.						
Pomeroy	2	5	100	2,784,000	278,000,000	1,748,000,000
Pittsburgh	3	4	45	3,840,000	173,000,000	
Lower Freeport	2	2	30	2,496,000	75,000,000	
Middle Kittanning	3	9	155	4,320,000	670,000,000	
Lower Kittanning	2	3	155	2,592,000	402,000,000	
Clarion	3	3	40	3,744,000	150,000,000	
Monroe County.						
Meigs Creek	3	9	155	4,320,000	670,000,000	2,913,000,000
Pittsburgh	4	0	320	4,608,000	1,475,000,000	
Upper Freeport	3	5	195	3,936,000	768,000,000	
Morgan County.						
Meigs Creek	3	8	85	4,224,000	359,000,000	6,669,000,000
Pittsburgh	4	4	20	4,992,000	100,000,000	
Upper Freeport	3	10	395	4,416,000	1,744,000,000	
Lower Freeport	2	3	320	2,592,000	829,000,000	
Middle Kittanning	5	5	400	6,240,000	2,496,000,000	
Lower Kittanning	2	5	410	2,784,000	1,141,000,000	

Estimated coal tonnage by beds and counties—Continued.

Muskingum County.

Name of coal bed.	Average thickness.		Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
	Ft.	*in.*				
Pittsburgh	2	6	10	2,880,000	29,000,000	4,836,000,000
"Norwich" (coal No. 7b)	2	2	10	2,496,000	25,000,000	
"New Concord" (coal No. 7a)	2	0	30	2,304,000	69,000,000	
Upper Freeport	4	1	300	4,704,000	1,411,000,000	
Lower Freeport	2	1	75	2,400,000	180,000,000	
Middle Kittanning	3	5	415	3,936,000	1,633,000,000	
Lower Kittanning	2	11	415	3,360,000	1,394,000,000	
Brookville	2	0	15	2,304,000	35,000,000	
Lower Mercer	2	0	15	2,304,000	35,000,000	
Quakertown (Wellston)	2	0	5	2,304,000	12,000,000	
Sharon	2	3	5	2,592,000	13,000,000	

Noble County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Meigs Creek	4	4	155	4,992,000	774,000,000	2,926,000,000
Pittsburgh	3	9	5	4,320,000	22,000,000	
Upper Freeport	4	3	405	4,896,000	1,983,000,000	
Middle Kittanning	2	3	30	2,592,000	78,000,000	
Lower Kittanning	2	0	30	2,304,000	69,000,000	

Perry County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Upper Freeport	4	10	60	5,568,000	334,000,000	2,141,000,000
Lower Freeport	3	11	60	4,512,000	271,000,000	
Middle Kittanning	6	1	120	7,008,000	841,000,000	
Lower Kittanning	2	9	145	3,168,000	459,000,000	
Clarion	1	5	80	1,632,000	131,000,000	
Tionesta	2	0	30	2,304,000	69,000,000	
Upper Mercer	1	7	20	1,824,000	36,000,000	

Portage County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Brookville	4	6	10	5,184,000	52,000,000	150,000,000
Lower Mercer	2	0	10	2,304,000	23,000,000	
Sharon	2	2	30	2,496,000	75,000,000	

Scioto County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Clarion	3	7	10	4,128,000	41,000,000	131,000,000
Tionesta	1	9	20	2,016,000	60,000,000	
Upper Mercer	1	9	15	2,016,000	30,000,000	

Stark County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Upper Freeport	2	9	5	3,168,000	16,000,000	1,873,000,000
Middle Kittanning	3	3	100	3,744,000	374,000,000	
Lower Kittanning	3	3	100	3,744,000	374,000,000	
Brookville	2	7	150	2,976,000	446,000,000	
Lower Mercer	2	2	50	2,496,000	125,000,000	
Quakertown	2	0	20	2,304,000	46,000,000	
Sharon	3	2	135	3,648,000	492,000,000	

Summit County.

Name of coal bed.	Ft.	in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Quakertown	2	6	30	2,880,000	86,000,000	542,000,000
Sharon	3	2	125	3,648,000	456,000,000	

Estimated coal tonnage by beds and counties—Continued.

Name of coal bed.	Average thickness. Ft.	Average thickness. in.	Area (sq. mi.).	Tons per square mile.	Tonnage by beds (in round numbers).	Tonnage for all beds (in round numbers).
Trumbull County.						
Sharon	2	0	10	2, 304, 000	23, 000, 000	23, 000, 000
Tuscarawas County.						
Upper Freeport	2	3	85	2, 592, 000	220, 000, 000	3, 135, 000, 000
Middle Kittanning	3	9	325	4, 320, 000	1, 404, 000, 000	
Lower Kittanning	2	11	325	3, 360, 000	1, 092, 000, 000	
Brookville	3	0	45	3, 456, 000	156, 000, 000	
	2	5	65	2, 784, 000	181, 000, 000	
Tionesta	2	3	25	2, 592, 000	65, 000, 000	
Upper Mercer	3	0	5	3, 456, 000	17, 000, 000	
Vinton County.						
Upper Freeport	3	0	20	3, 456, 000	69, 000, 000	2, 584, 000, 000
Lower Freeport	3	4	10	3, 840, 000	38, 000, 000	
Middle Kittanning	3	6	115	4, 032, 000	464, 000, 000	
Lower Kittanning	1	11	115	2, 208, 000	254, 000, 000	
Clarion	3	3	110	3, 744, 000	412, 000, 000	
Brookville	3	4	90	3, 840, 000	346, 000, 000	
Tionesta	2	6	15	2, 880, 000	43, 000, 000	
Upper Mercer	2	11	75	3, 360, 000	252, 000, 000	
Lower Mercer	2	11	130	3, 360, 000	437, 000, 000	
Quakertown (Wellston)	2	9	85	3, 168, 000	269, 000, 000	
Washington County.						
Meigs Creek	4	0	100	4, 608, 000	461, 000, 000	3, 345, 000, 000
Pittsburgh	2	5	120	2, 784, 000	334, 000, 000	
Upper Freeport	3	2	120	3, 648, 000	438, 000, 000	
Middle Kittanning	4	2	440	4, 800, 000	2, 112, 000, 000	
Wayne County.						
Lower Mercer	2	4	30	2, 880, 000	86, 000, 000	301, 000, 000
Sharon	4	8	40	5, 376, 000	215, 000, 000	

	Short tons.
Total original tonnage in round numbers of all beds in all counties	87, 638, 000, 000
Total coal mined in Ohio to end of 1915	723, 956, 352
Wasted in mining or rendered useless, estimated, in round numbers	362, 000, 000
Amount remaining and available, in round numbers	86, 552, 000, 000

The principal part of the tonnage, according to this estimate, is contained in seven coal beds, the outcrops of which are shown on the coal maps described above. These beds, in the order of their tonnage, are as follows: Middle Kittanning, 22,926,000,000 tons; Upper Freeport, 16,732,000,000 tons; Lower Kittanning, 14,674,000,000 tons; Lower Freeport, 6,971,000,000 tons; Pittsburgh, 6,863,000,000 tons; Meigs Creek, 4,071,000,000 tons; and Pomeroy, 710,000,000 tons. The total for these beds is 72,947,000,000 tons, or more than 83 per cent of the total tonnage of the State. The first three beds contain 54,332,000,000 tons, or more than 61 per cent of the total coal of the State.

From this showing it is evident that the total tonnage of those coal beds for which there are no outcrop maps is relatively small (only about 17 per cent of the entire estimate), and even if some errors have been made in estimating their areas and average thicknesses such errors will not greatly affect the total tonnage. Furthermore, the Anthony, Bear Run, "Lost

Seam," Mahoning, Mason, and Vandusen coal beds, which are thin local beds in the southern counties that are not included in the figures, will tend to offset an overestimate of other beds.

Recent detailed work done in southern Ohio by the State Survey[1] materially affects the estimate for that area made in 1912. The recent investigations tend to reduce the total tonnage, although for a few beds the area and thickness were increased.

In the earlier reports certain beds were said to be persistent and of good thickness throughout large areas, whereas recent detailed work in the southern counties shows that these beds vary in thickness and are restricted to small areas. Therefore, if the earlier reports contain the same kind of error regarding the coal in other parts of the State, the present estimate may be too large, but any further reduction is unwarranted until further detailed work is completed.

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[1] Ohio Geol. Survey Bull. 20, 1916.

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